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OATS IN THE GREAT PLAINS AREA: RELATION OF CULTURAL METHODS TO PRODUCTION.

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INTRODUCTION.

This bulletin contains a study of the yields of oats from different methods of cultivation and seed-bed preparation at fourteen field stations on the Great Plains.

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The following-named men have held positions on the scientific staff of the Office of Dry-Land Agriculture during the past nine years, but have resigned or have been transferred to other offices of the Department of Agriculture: Sylvester Balz, F. L. Kennard, J. E. Payne, L. E. Hazen, C. A. Jensen, H. R. Reed, W. O. Whitcomb, C. H. Plath, F. Knorr, and R. W. Edwards.

The data here reported from the stations in Kansas, Nebraska, North Dakota, and Montana have been obtained in cooperation with the agricultural experiment stations of their respective States. In South Dakota, Colorado, Texas, Oklahoma, and New Mexico the stations are operated by the United States Department of Agriculture.

Field, office, and laboratory facilities, teams, and implements have been provided by the Office of Western Irrigation Agriculture, at Huntley, Mont., Belle Fourche, S. Dak., and Mitchell, Nebr., and by the Office of Cereal Investigations at Amarillo, Tex., and Archer, Wyo. The Biophysical Laboratory has cooperated in obtaining the meteorological data reported.

Note.—This bulletin is intended for all who are interested in the agricultural possibilities of the Great Plains area.

The study as here made shows the effect of the cropping and cultivation of the land in only the one year preceding the growth of the oats. A study of the cost of production by each of the methods under trial and the resulting profit or loss are also given.

Results are presented from an aggregate of 74 station years, involving an aggregate of 2,115 plat years. By station year is meant one year at one station; by plat year is meant one plat at one station for one year.

Such a mass of material furnishes an infinite amount of detail for study, but it is the purpose of this bulletin to consider only the broader bearings and more obvious and important phases of the work, rather than a study of the details.

This bulletin, dealing with only the one crop, does not afford a measure for judging the agricultural possibilities for other crops of any section of the region. The Office of Dry-Land Agriculture of the United States Department of Agriculture began field work in the investigation of methods of crop production in the Great Plains in 1906. The work begun at that time has been constantly added to until 20 stations were in operation in 1914. Data from only 14 of these stations are here presented; those that have records of but one or two years are not included.

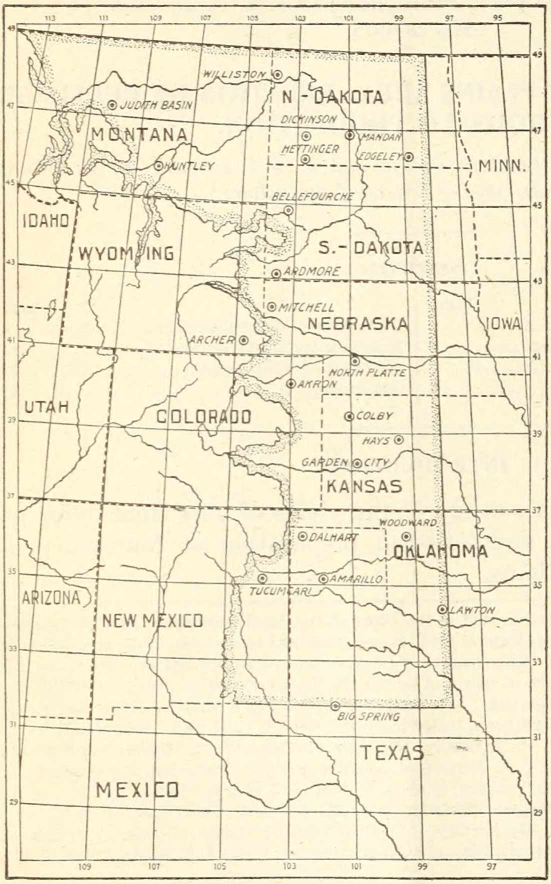


FIG. 1.—Sketch map of the Great Plains area, which includes parts of ten States and consists of about 400,000 square miles of territory. Its western boundary is indicated by the 5,000-foot contour. The location of each field station within the area is shown by a dot within a circle (⊙).

The method of work adopted was that of raising the different crops both in different combinations or systems of rotation and under different methods of cultivation in systems of continuous cropping. In no case have rotations of over six years in length been used. Those of even this length have been tried only with sod crops. More of the work has been done with 3-year and 4-year rotations.

AREA INCLUDED IN THESE INVESTIGATIONS.

The area covered by these investigations is shown in figure 1 and consists of about 400,000 square miles of territory. It includes the western parts of North Dakota, South Dakota, Nebraska, Kansas, Oklahoma, and Texas, and the eastern portions of Montana, Wyoming, Colorado, and New Mexico. The fact that the determining factor in crop production is the limited rainfall is responsible for a general uniformity in conditions throughout the area. There is, however, a wide range of soil, climatic conditions, and altitude. The lowest station is Edgeley, N. Dak., with an altitude of 1,468 feet and the highest is Archer, Wyo., with an altitude of 6,012 feet. The length of the growing season for oats is naturally much the same throughout the area, but there is a variation of approximately a month to six weeks in the respective dates of seeding and harvesting oats, the southern section using the earlier dates.

CLIMATIC CONDITIONS.

The area is characterized by a varying amount of annual and seasonal precipitation, with very uncertain distribution. Years of relatively high precipitation with favorable distribution may be followed by years of relatively low precipitation with very unfavorable distribution. It may be said that the uncertainty of the distribution rather than the total amount of rainfall received is the factor that makes crop production hazardous. In connection with this work, complete climatic data have been obtained. It is not practicable, however, to give them in this publication. Table I shows the minimum, maximum, and average annual and seasonal rainfall and the seasonal evaporation at each station for the years for which the yields are here reported. By seasonal is meant the precipitation or evaporation for the period between the average time of seeding and the average time of harvesting. No attempt is made here to show any of the other climatic factors or the amount of water already in the soil at seeding time, any one of which may have an important influence on yields. The annual precipitation as here given is not the annual as determined from the complete record, but is the average annual precipitation of the years whose results are under study.

TABLE I.—*Annual and seasonal precipitation and seasonal evaporation at fourteen stations in the Great Plains area.*[1]

Station.	Altitude[2] (feet).	Precipitation[3] (inches).						Seasonal evaporation[3] (inches).		
		Annual.			Seasonal.					
		Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.	Minimum.	Maximum.	Average.
Judith Basin	4,228	14.96	23.78	18.06	6.50	10.90	8.62	19.117	26.273	21.330
Huntley	3,000	11.92	11.92	11.92	5.00	7.35	6.18	19.820	20.594	20.207
Williston	1,875	10.28	18.99	14.84	5.62	12.00	8.31	21.104	28.269	24.705
Dickinson	2,543	11.93	21.22	16.69	5.31	16.27	10.06	18.379	27.366	22.377
Edgeley	1,468	11.94	21.95	16.71	5.08	15.73	9.60	17.664	25.362	20.657
Hettinger	2,253	12.72	15.68	14.20	8.82	12.89	10.69	20.111	24.248	22.430
Belle Fourche	2,950	6.64	17.73	13.11	1.92	12.75	6.82	23.627	33.906	27.220
Scottsbluff	3,950	13.77	18.51	16.14	5.56	8.26	7.11	24.698	26.647	25.718
North Platte	3,000	11.18	23.01	18.05	4.38	11.25	7.77	25.954	35.255	30.253
Akron	4,600	14.51	22.46	18.28	5.32	9.52	7.82	25.917	32.691	28.781
Hays	2,050	15.59	27.80	21.30	3.87	12.87	9.55	29.390	41.317	32.628
Garden City	2,900	11.82	23.58	18.54	5.01	8.16	6.85	33.315	38.926	35.332
Dalhart	4,000	13.69	16.35	15.11	4.54	14.86	8.17	33.381	41.002	38.596
Amarillo	3,676	10.69	27.80	18.28	5.03	11.49	7.05	32.305	40.704	36.709

[1] The years covered are the same as for the data shown in the other tables for the several stations.

[2] The altitude given is for the field where the work was done and is based in most cases on that of the nearest town.

[3] The record of annual precipitation for 1914 is not included. The records of seasonal precipitation and evaporation for 1914 are included for all stations, the evaporation being figured from Apr. 1 to July 31. The seasonal rainfall is the measurement from Apr. 1 to July 31 for stations north of and including that at Belle Fourche. For stations south of Belle Fourche it is the amount between Mar. 1 and June 30. Evaporation measurements are made from a free water surface, in a tank sunk into the soil to almost its full depth. The water surface is kept about level with the surface of the ground.

GENERAL PLAN OF THE INVESTIGATIONS.

The same variety of oats is used on all plats at a station during any one year. The intention is to use the best variety that is available for general use. Changes are made only when seed breeding, selection, or varietal testing makes available for general use a better variety. No attempt is made to use the same variety at different stations. The rate, time, and manner of seeding are the same for all plats at a station in any one year. As compared with more humid sections, the seeding is light, the usual rate being 6 pecks per acre. All seeding is done with a drill, rows being spaced from 6 to 8 inches apart, depending upon the locality. In different places different styles of drills are used.

In the present study a table is presented for each station. The first part of such table shows the yields that have been obtained in each year by each of the different methods under which oats have been grown, considering only the variations in the one year preceding the crop. The previous crop whose stubble was treated as specified is also shown. Where more than one plat has been under the same treatment for the previous year, only the average yield of the whole number of plats so grown is given. Column 2 of the table shows the number of plats so averaged. The succeeding columns need no explanation, as they show the yields for each year as indicated and the averages of each method for the whole period of years. In the last column, where the average appears under the heading "Average," the calculation is from the left. The averages of the different methods of treatment are the averages of the whole number of plats that entered into their composition. For a rough comparison of seasons the bottom line of the first half of the table gives the averages of all plats for each year, the average of the yearly average yields appearing in the last column to the right.

As here presented the treatment of the land is specified as fall plowed, spring plowed, sod breaking, subsoiled, listed, disked, green manured, and summer tilled. Under these headings are subdivisions to show the preceding crop.

Where oats appear following wheat on either fall or spring plowed land it has been in rotations of at least 3 years in length. Where oats follow oats the system has been that of continuous cropping.

Fall plowing is done as early as practicable and to a good depth, the standard being set at 8 inches. The ground after being plowed may be worked down or left rough through the winter, as seems advisable. Spring plowing is done as early as practicable in the spring, with the exception of one plat at each station, on which oats follow oats. It is done to a good depth, about 8 inches, and given sufficient cultivation with the harrow, or disk if necessary, to form a good seed bed. On one plat which is continuously cropped to oats at each station, spring plowing is shallow (only about 4 inches) and is given a minimum of cultivation.

Sod is broken in the fall as early as hay production for the year is over.

Subsoiling is done on land continuously cropped to oats. The treatment of the plat that appears at some stations under this heading is the same as the treatment of the plat that appears under "Fall plowed," except that it is subsoiled. At the time of plowing a subsoiler is run in every other furrow to an additional depth of 6 or 8 inches, making a total depth of about 14 inches. This is usually done two years in succession and then omitted for two years.

The plat that appears at some stations under the heading "Listed," following oats, is a plat continuously cropped to oats. At the time of fall plowing this plat is furrowed out with the lister instead of being plowed. In the spring it is worked down level and the seed bed prepared without the use of the plow.

The plats on disked corn ground are all in rotation with other crops. Both 3-year and 4-year rotations comprise this series. The other crops may be winter wheat, spring wheat, barley, green manure, or potatoes. In some of the rotations summer tillage replaces one of the crops.

Where oats are grown after a green-manure crop the system is that of a 4-year rotation in which one crop is corn and the other one of the small grains.

Summer tillage is of the intensive type. The land lies fallow for a year. It is kept clear of weeds and as far as practicable a mulch is maintained on it during the time between the harvest of the preceding crop and the seeding of the oats. This involves a period in some cases as long as 21 months. In some cases it is necessary to plow the land more than once during this period, in order either to maintain a surface receptive to water and that will resist blowing or to prevent the growth of weeds. The long period of summer tillage, together with the intensive methods practiced, have made this an expensive system of production. Experiments are under way to determine the most economical method of summer tilling. Indications are that a less intensive method than that practiced in the work here reported will give practically as good returns.

The yields given in these tables begin with the second year of crop production at each station. The first year's crop is produced on land uniform in its treatment.

In cases where an entire crop has been lost by hail or other agency that could not possibly be overcome by cultivation the years are not considered in computing averages. Such failures must of course enter into the final results of agricultural endeavor. They are, however, of such uncertain occurrence that the series of years here considered is too short to permit an attempt to establish their normal frequency for any locality. This is in effect what would be done by including them in averages. It is believed that less error is introduced by recognizing their occurrence and excluding them from averages. When the loss of a crop is due to conditions that might possibly have been overcome by cultural practices a zero yield for that year is included in the calculations.

Embodying the basic data given in Tables II, III, and IV, the second part of the table for each station has been compiled. In this are brought together in summary form the yields detailed in the first part of such table. The value of the average yields thus obtained is calculated and given, together with a computation of the cost of production. The last line of the table gives the profit or loss resulting from the production of oats by the method stated. Loss is indicated by the minus sign. In this second part of each table there are two general headings: "Tillage treatment" and "Previous crop." Under the first general heading the plats are grouped entirely by treatment without considering the previous crop. Under the second heading treatment is not considered, and the grouping is entirely governed by the crop immediately preceding the oats. This really makes two tables combined in one, with subdivisions common to both.

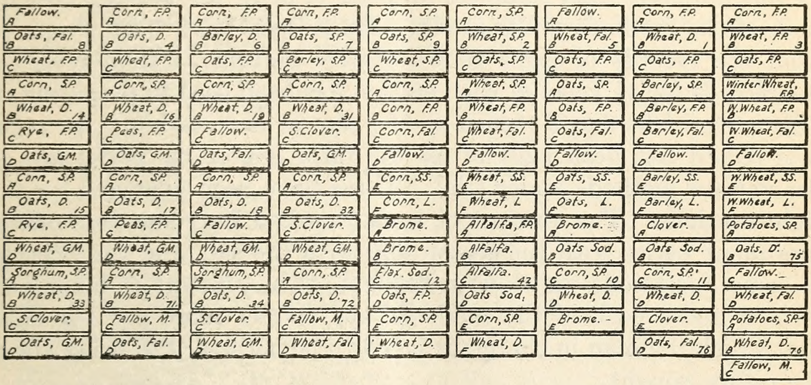
Figure 2 shows a diagram of the dry-land rotation field at the Belle Fourche Field Station. This station being a representative one will serve to illustrate the general scheme and plan of work.

The plats here, as in all of the work, are one-tenth acre in size. Their dimensions are 2 by 8 rods. Along their larger dimension the plats are separated by bare alleys 4 feet in width. Along the ends of the plats they are separated by roads 20 feet wide.

At this station five crops are represented in a series of continuously cropped plats lettered from A to F. In this group, plats C and D are alternately cropped and summer tilled, so that each year a crop is grown on land that was summer tilled the previous year, and a plat is summer tilled for cropping the next year.

The remainder of the field is in rotations in which each plat is known by a rotation number and letter. On the field diagram the separation of rotations is indicated by heavy lines.

The movement of the crops is in the direction from Z to A and from A back to the letter that marks the other end of the rotation.



A Fallow.	A Corn, F.P.	A Corn, F.P.	A Corn, F.P.	A Corn, S.P.	A Corn, S.P.	A Fallow.	A Corn, F.P.	A Corn, F.P.
B Oats, Fal. 8	B Oats, D. 4	B Barley, D. 6	B Oats, S.P. 7	B Oats, S.P. 9	B Wheat, S.P. 2	B Wheat, Fal. 5	B Wheat, D. 1	B Wheat, F.P. 3
C Wheat, F.P.	C Wheat, F.P.	C Oats, F.P.	C Barley, S.P.	C Wheat, S.P.	C Oats, S.P.	C Oats, F.P.	C Oats, F.P.	C Oats, F.P.
A Corn, S.P.	A Corn, S.P.	A Corn, S.P.	A Corn, S.P.	A Corn, S.P.	A Wheat, S.P.	A Oats, S.P.	A Barley, S.P.	A Winter Wheat, F.P.
B Wheat, D. 14	B Wheat, D. 16	B Wheat, D. 19	B Wheat, D. 31	B Corn, F.P.	B Wheat, F.P.	B Oats, F.P.	B Barley, F.P.	B W. Wheat, F.P.
C Rye, F.P.	C Peas, F.P.	C Fallow.	C S. Clover.	C Corn, Fal.	C Wheat, Fal.	C Oats, Fal.	C Barley, Fal.	C W. Wheat, Fal.
D Oats, G.M.	D Oats, G.M.	D Oats, Fal.	D Oats, G.M.	D Fallow.	D Fallow.	D Fallow.	D Fallow.	D Fallow.
A Corn, S.P.	A Corn, S.P.	A Corn, S.P.	A Corn, S.P.	E Corn, S.S.	E Wheat, S.S.	E Oats, S.S.	E Barley, S.S.	E W. Wheat, S.S.
B Oats, D. 15	B Oats, D. 17	B Oats, D. 18	B Oats, D. 32	F Corn, L.	F Wheat, L.	F Oats, L.	F Barley, L.	F W. Wheat, L.
C Rye, F.P.	C Peas, F.P.	C Fallow.	C S. Clover.	A Brome.	A Alfalfa, F.P.	A Brome.	A Clover.	A Potatoes, S.P.
D Wheat, G.M.	D Wheat, G.M.	D Wheat, G.M.	D Wheat, G.M.	B Brome.	B Alfalfa.	B Oats Sod.	B Oats Sod.	B Oats, D. 75
A Sorghum, S.P.	A Corn, S.P.	A Sorghum, S.P.	A Corn, S.P.	C Flax. Sod. 12	C Alfalfa. 42	C Corn, S.P. 10	C Corn, S.P. 11	C Fallow.
B Wheat, D. 33	B Wheat, D. 71	B Oats, D. 34	B Oats, D. 72	D Oats, F.P.	D Oats Sod.	D Wheat, D.	D Wheat, D.	D Wheat, Fal.
C S. Clover.	C Fallow, M.	C S. Clover.	C Fallow, M.	E Corn, S.P.	E Corn, S.P.	E Brome.	E Clover.	A Potatoes, S.P.
D Oats, G.M.	D Oats, Fal.	D Wheat, G.M.	D Wheat, Fal.	F Wheat, D.	F Wheat, D.		D Oats, Fal. 76	B Wheat, D. 76
								C Fallow, M.

FIG. 2.—Diagram of the dry-land rotation field at the Belle Fourche Field Station. The lettering shows the cropping practiced in 1914. The explanation of abbreviations used after the name of a crop is as follows: *D.*=Disked, *Fal.*=summer tilled, *F. P.*=fall plowed, *G. M.*=green manured, *L.*=listed, *M.*=manured, *S. P.*=spring plowed, *S. S.*=subsoiled.

In figure 2 the diagram is filled out to show the cropping in 1914. The letters following the crop indicate the treatment given the ground in preparation for it, S. P. standing for spring plowed, F. P. for fall plowed, Fal. for summer tilled, G. M. for green manured, and D. for disked. The addition of the letter M. indicates the use of manure.

To illustrate: In 1914 plat A of the 4-year rotation No. 14 was in corn on spring-plowed ground, plat B was in wheat on disked corn ground, and plat C was in winter rye on fall-plowed land. This would be plowed under for green manure. Plat D was in oats where winter rye had been turned under the year before. In 1915 A will be in wheat, B in winter rye, C in oats, and D in corn.

Some of the rotations are calculated to conserve or increase the fertility of the soil, while others may perhaps deplete it. In the present stage of the work the effects of rotations as units are greatly overshadowed by the effects of the cropping and cultivation of a single year. This is due to the fact that the controllable factors are water supply, physical condition of the seed bed, and a certain recognized, if not understood, effect of the crop immediately preceding. Uniformity in these factors is largely restored by the cultivation or cropping of a single season. After a careful study of the data, it seems advisable at the present time to prepare a series of bulletins discussing in each the results relating to but one crop as determined by the treatment of the land in only the one year immediately preceding the growth of the crop.

COMPARISON OF CULTURAL METHODS.

The methods under study vary a great deal in the labor involved and in the consequent cost of production by each method. Table IV has therefore been compiled in order to show the average cost by each of the methods under study. These data have been prepared from the records of eight representative stations. An average of the records for 5½ years at each station has been used in preparing it. This is equivalent to a record of 44 years at one station. An accurate record has been kept of all the farm operations performed in the various methods under trial. These have been averaged for the eight stations. The amount of work required for some methods of treatment varies with the season and with the soil, and the expense of some operations varies with the soil. The amount of labor performed under each of the methods was neither more nor less than that which the man in charge believed to be necessary to bring about the results sought.

In computing the cost of the various operations a fixed wage of $2 a day for a man and $1 a day for a horse was adopted. This may be above or below the actual labor cost in any particular locality, but it is believed to be a fair average and one that will afford a profitable market to the farmer for his labor. The time required of men and teams to cover a given acreage in each of the several farm operations obviously varies with soils and other conditions. The average shown in Table II has been determined from the actual experience of a large number of men connected with these investigations, experience that has extended over a wide range of conditions and many years of time.

The factors included in the cost of production are calculated on an acre basis for each of the separate operations performed, beginning with the preparation of the land and ending with the harvesting and shocking of the grain. To these items are added the cost of seed at 60 cents per acre, interest and taxes on the land investment calculated at 8 per cent on a valuation of $20 per acre, and the deterioration and repairs of the binder at 15 cents per acre. No allowance is made for the deterioration of other farm equipment, as it is believed that the wages allowed for men and teams are sufficient to cover this item for the remainder of the equipment. The above-mentioned items are fixed charges per acre; that is, they do not vary greatly with the yield per acre except for the item of twine, but this variation is not sufficient to affect materially the relative total cost of production under the several methods.

Table II shows the cost per acre, based upon what is considered an average day's work for each of the farm operations involved, at the above-mentioned wage. As before stated, the type of soil and seasonal conditions will determine to a certain extent the labor required and the consequent cost per acre.

TABLE II.—*Average cost per acre*[1] *of the farm operations involved in growing oats in the Great Plains area.*

[The wage scale assumed is $2 per day for each man and $1 per day for each horse.]

Operation.	Force employed.		Day's work.	Item cost.	Cost per acre.
	Men.	Horses.			
			Acres.		
Plowing	1	4	3½		$1.71
Disking	1	4	8		.75
Harrowing	1	4	35		.17
Subsoiling	1	3	3½		1.43
Drilling	1	4	15		.40
Cultivating	1	4	16		.38
Listing	1	4	10		.60
Harvesting:					
Cutting and binding	1	4	15	$0.40	.93
Shocking	1			.13	
Twine				.25	
Binder wear and repair				.15	

[1] The cost of thrashing is not included in the cost per acre, but it is estimated at 5 cents per bushel and deducted from the price of 35 cents in the granary, thus giving a value of 30 cents per bushel in the shock.

The average farm price of oats used in these computations is based on the data given in Table III, furnished by the Bureau of Crop Estimates. The four States of Kansas, Nebraska, North Dakota, and South Dakota were selected because their extensive oat production has given them established market prices which are not greatly influenced by local conditions. As given in Table III, the average farm price of oats on December 1 for the past 10 years has been nearly 35 cents per bushel. It costs about 5 cents per bushel to take the grain from the shock, thrash it, and put it in the granary on the farm. This cost per bushel does not vary greatly with the yield and is therefore a fixed price per bushel instead of a fixed price per acre, as is the case with the other costs of production. The relative profits of producing oats under the different methods can therefore best be determined by finding the difference between the fixed cost per acre and the value per acre of the grain at the point where the fixed cost per acre ends, which, as before stated, is when the grain is in the shock. Knowing that the average farm value of oats in the granary is 35 cents per bushel, and that it costs 5 cents per bushel to take it from the shock, thrash it, and put it in the granary, it is obvious that it would be worth 30 cents per bushel in the shock. This valuation of 30 cents per bushel has therefore been used as a basis for calculating the relative crop values, costs, and profits per acre of the various methods under trial.

TABLE III.—*Average price of oats at the farm granary for 10 years in four States of the Great Plains area.*

[The quotations are given in cents per bushel. Those for the year 1914 are for the date of Nov. 1; in other years Dec. 1 is taken as the date.]

Year.	North Dakota.	South Dakota.	Nebraska.	Kansas.	Average.
1905	23	23	24	28	24½
1906	27	25	26	31	27¼
1907	40	39	37	42	39½
1908	42	41	41	45	42¼
1909	33	34	35	43	36¼
1910	37	30	28	34	32¼
1911	41	43	43	45	43¾
1912	22	25	30	35	28
1913	30	34	38	45	36¾
1914	36	38	39	43	39
Average	33	33	34	39	34¾

In conformity with the foregoing explanation, Table IV gives in detail the cost of producing oats in the shock, expressed in dollars and cents and in bushels per acre at 30 cents per bushel. These prices are used as a working basis and are not offered as being exact. It is fully realized that the price of any or all factors used in obtaining them may vary locally from the fixed price assumed.

TABLE IV.—*Cost per acre of producing oats in the shock in the Great Plains area, showing averages of data from eight stations.*

Method of preparation.	Number of operations.						Cost of preparation.	Cost per acre.				Total cost of production.	
	Plowing.	Harrowing.	Disking.	Subsoiling.	Listing.	Drilling.		Seed.	Drilling.	Harvesting.	Interest and taxes.	In dollars.	In grain, at 30 cents per bushel.
Disked corn land		1.3	1				$0.97	$0.60	$0.40	$0.93	$1.60	4.50	15.0
Listed		1.6	1.2		1		1.77	.60	.40	.93	1.60	5.30	17.7
Spring plowed	1	1.3	.5				2.31	.60	.40	.93	1.60	5.84	19.5
Fall plowed	1	2.3	.9				2.78	.60	.40	.93	1.60	6.31	21.0
Subsoiled	1	1.7	.9	0.5			3.39	.60	.40	.93	1.60	6.92	23.1
Summer tilled	1.5	9.2	2.6				6.12	.60	.40	.93	3.20	11.25	37.5
Green manured:													
With rye[1]	2	6.5	2.4			1	7.73	.60	.40	.93	3.20	12.86	42.9
With peas[2]	2	5.8	2.7			1	10.73	.60	.40	.93	3.20	15.86	52.9
Average cost of green manuring												14.36	47.9

[1] The cost of rye per acre for seed is estimated at $1.
[2] The cost of peas per acre for seed is estimated at $4.

RESULTS AT THE SEVERAL STATIONS.

Accompanying the discussion of each station is a very brief description of the soil, with particular reference to its depth and its water-holding capacity. Only such information is given as is necessary to understand fully the interpretation of the results.

JUDITH BASIN FIELD STATION.

The field station at Moccasin, Mont., in the Judith Basin, is located on a heavy clay soil of limestone origin. The soil is apparently very rich in available fertility. It is underlain at a depth of approximately 3 feet by a limestone gravel that is closely cemented with lime materials. The gravel subsoil, which extends to a depth of about 30 feet, is practically free from soil. While it is so closely cemented that it does not unduly drain the soil, it is not of a character that allows the storage of available water or the development of roots within it. The presence of gravel in the surface soil does not permit the taking of samples satisfactory for the study of soil moisture. Enough has been done, however, to make it certain that the supply of water that can be stored in this soil is limited. This shallowness of the soil and consequent limitation of the quantity of water that can be stored in it and recovered by the crop makes the crop dependent in large part upon the rains that fall while it is growing.

While the oat crop is not at present the most important commercial crop in the Judith Basin, good yields have been obtained at this field station and a profit realized by all methods under trial. In 1912 the crop was destroyed by a local hail storm. Yields have therefore been calculated on the basis of five years. In the experiments in crop rotation and cultivation methods, 33 plats of oats have been grown each year. This number was increased by the addition of new work in 1913, but only work started in 1908 is here reported. As here presented, the results are arranged to study only the effect of cropping and cultivation in the one year preceding the growth of oats. No attempt is made to study rotations as units.

Table V shows that while there may be great seasonal variations in yields the differences resulting from cultural conditions are generally small. With the exception of the comparatively high yield by summer tillage and the low yield on both brome-grass and alfalfa sods and following flax on brome-grass sod, the differences in yield from different preparations are too small to have meaning.

The low yields on brome-grass and alfalfa sod and following flax on brome-grass sod are due to the fact that at this station sod crops recover after breaking to such an extent as to choke out the oats. The profitableness of these crops in themselves, together with the poor results which follow their breaking, indicates that the sod crops should remain down for long periods rather than enter into short rotations.

TABLE V.—*Yields and cost of production of oats by different methods at the Judith Basin Field Station, 1909 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels.)						
		1909	1910	1911	1912	1913	1914	Average.
Fall plowed:								
Wheat	6	[1] 64.9	[1] 20.5	53.0	(2)	62.8	53.0	50.8
Oats	1	66.2	20.9	51.5	(2)	65.0	49.3	50.6
Barley	1	57.8	19.3	53.7	(2)	64.4	54.0	49.8
Winter wheat	1	....	....	53.1	(2)	70.6	52.1	58.6
Flax	1	63.7	19.5	45.7	(2)	33.7	46.2	41.8
Total or average	10	63.9	20.2	52.2	....	61.1	52.0	49.9
Spring plowed:								
Wheat	1	63.1	25.3	51.5	(2)	54.5	45.3	47.9
Oats	1	75.3	24.3	52.0	(2)	64.1	44.6	52.1
Corn	2	72.4	23.1	54.5	(2)	63.1	49.2	52.5
Total or average	4	70.8	24.0	53.1	....	61.2	47.1	51.2
Sod breaking:								
Alfalfa	1	56.8	14.3	33.1	(2)	30.6	47.1	36.4
Brome-grass	2	62.5	17.8	22.5	(2)	38.6	21.5	32.6
Clover	1	72.5	22.8	37.8	(2)	50.3	50.6	46.8
Total or average	4	63.6	18.2	29.0	....	39.5	35.2	37.1
Subsoiled: Oats	1	63.7	25.3	53.0	(2)	65.0	40.6	49.5
Listed: Oats	1	72.5	22.8	53.5	(2)	63.4	37.5	49.9
Disked: Corn	6	[3] 57.3	[3] 24.4	55.6	(2)	75.1	54.2	53.3
Green manured:								
Rye	2	68.7	25.7	56.8	(2)	75.9	54.3	56.3
Peas	2	71.2	21.0	52.0	(2)	75.3	46.7	53.2
Total or average	4	69.9	23.4	54.4	....	75.6	50.5	54.8
Summer tilled	3	70.5	23.6	63.2	(2)	76.2	58.7	58.4
Average of all 33 plats	....	65.5	22.2	51.4	....	64.3	49.4	50.6

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment.							Previous crop.			
	Fall plowed (10 plats).	Spring plowed (4 plats).	Disked (6 plats).	Listed (1 plat).	Subsoiled (1 plat).	Green manured (4 plats).	Summer tilled (3 plats).	Sod (4 plats).	Corn (8 plats).	Small grain (13 plats).	Flax (1 plat).
Yields of grain:											
1909......bushels..	63.9	70.8	57.3	72.5	63.7	69.9	70.5	63.6	61.6	65.8	63.7
1910..........do....	20.2	24.0	24.4	22.8	25.3	23.4	23.6	18.2	24.0	22.0	19.5
1911..........do....	52.2	53.1	55.6	53.5	53.0	54.4	63.2	29.0	55.3	52.8	45.7
1912..........do....	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)	(2)
1913..........do....	61.1	61.2	75.1	63.4	65.0	75.6	76.2	39.5	72.1	63.4	33.7
1914..........do....	52.0	47.1	54.2	37.5	40.6	50.5	58.7	35.2	53.0	49.3	46.2
Average	49.9	51.2	53.3	49.9	49.5	54.8	58.4	37.1	53.2	50.7	41.8
Crop value, cost, etc.:											
Value	$14.97	$15.36	$15.99	$14.97	$14.85	$16.44	$17.52	......	......	......	......
Cost	6.31	5.84	4.50	5.30	6.92	14.36	11.25	......	......	......	......
Profit	8.66	9.52	11.49	9.67	7.93	2.08	6.27	......	......	......	......

[1] Only 4 plats in 1909 and 1910.
(2) Destroyed by hail.
[3] Only 5 plats in 1909 and 1910.

When the cost of production is taken into consideration, as in the last part of Table V, it is seen that the less expensive methods are more profitable. This is a direct result of the lack of differences in crop values as great as the differences in cost of production. Great freedom is offered the farmer in the choice of the place he will give oats in his cropping system and in the manner in which he will prepare the land for the crop.

HUNTLEY FIELD STATION.

The field station at Huntley, Mont., is located in the valley of the Yellowstone River, just below the first bench. The soil is a heavy gumbo to a depth of about 8 feet. Underlying the soil is a considerable depth of freely drained gravel. This soil carries a large supply of available water and allows deep feeding of the crop. Consequently, it is possible to store in it a maximum quantity of water that can be recovered by the crop.

Data of only two years are available from the Huntley station. These both have been years of heavy production. The results of two years are not sufficient evidence on which to draw conclusions, but may be of value as indicators. The extreme range by different preparations in the average of the two years has been from 41.2 bushels on fall-plowed oat ground to 62.1 bushels after peas as green manure.

In both years the yield by both spring and fall plowing has been heavier on wheat stubble than on oat stubble. In both years the yield has been heavier by spring plowing than by fall plowing of either wheat or oat stubble.

As compared with similar oat stubble fall plowed, there has been a small increase in yields each year as a result of subsoiling. The average of this increase has been 4.9 bushels per acre. But a still further increase of 1.1 bushels per acre has resulted from furrowing with a lister and leaving the ground rough through the winter instead of plowing. The yields following corn have averaged heavier than those following small grain, but not as heavy as those following either summer tillage or green manure. Disking corn ground has been as good a preparation as plowing it. The highest average yields have been obtained by summer tillage and green manure.

A profit has been realized from the production of the crop by all the methods under trial. The smallest profit, $3.22 per acre, has been by the most expensive method, green manuring. The largest profit, $11.40 per acre, has been by the least expensive method, disking corn ground. Spring plowing and listing are of about equal rank, with profits of nearly $9 per acre. Fall plowing, subsoiling, and summer tillage have each given an annual profit of about $7 per acre.

TABLE VI.—*Yields and cost of production of oats by different methods at the Huntley Field Station, 1913 and 1914.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels). 1913	1914	Average.
Fall plowed:				
Wheat	4	37.5	50.4	44.0
Oats	1	34.0	48.4	41.2
Barley	1	34.0	52.3	43.2
Total or average	6	36.4	50.4	43.4
Spring plowed:				
Wheat	1	42.8	55.6	49.2
Oats	1	35.3	50.6	43.0
Corn	2	44.4	60.3	52.4
Total or average	4	41.7	56.7	49.2
Sod breaking:				
Alfalfa	1	46.9	51.9	49.4
Brome-grass	1	51.9	43.7	47.8
Total or average	2	49.4	47.8	48.6
Subsoiled: Oats	1	39.3	52.8	46.1
Listed: Oats	1	45.6	48.7	47.2
Disked: Corn	8	43.7	62.2	53.0
Green manured:				
Rye [1]	2	46.2	63.9	55.1
Peas	2	64.5	59.7	62.1
Total or average	4	55.4	61.8	58.6
Summer tilled	3	60.8	57.6	59.2
Average of all 29 plats	....	45.6	56.7	51.2

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment. Fall plowed (6 plats).	Spring plowed (4 plats).	Disked (8 plats).	Listed (1 plat).	Sub-soiled (1 plat).	Green manured (4 plats).	Summer tilled (3 plats).	Previous crop. Corn (10 plats).	Small grain (10 plats).	Sod (2 plats).
Yields of grain:										
1913...bushels..	36.4	41.7	43.7	45.6	39.3	55.4	60.8	43.8	38.1	49.4
1914.......do....	50.4	56.7	62.2	48.7	52.8	61.8	57.6	61.8	51.0	47.8
Average.......	43.4	49.2	53.0	47.2	46.1	58.6	59.2	52.8	44.6	48.6
Crop value, cost of production, etc.:										
Value..........	$13.02	$14.76	$15.90	$14.16	$13.83	$17.58	$17.76	....	....	....
Cost..........	6.31	5.84	4.50	5.30	6.92	14.36	11.25	....	....	....
Profit.........	6.71	8.92	11.40	8.86	6.91	3.22	6.51	....	....	....

[1] Barley was used as green manure in 1912.

WILLISTON FIELD STATION.

The experimental work at Williston, N. Dak., is conducted on a silt soil that carries a considerable supply of available water and on which the depth of feeding is limited only by the depth to which the character of the crop limits the development of roots.

Table VII.—*Yields and cost of production of oats by different methods at the Williston Field Station, 1910 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).					
		1910	1911	1912	1913	1914	Average.
Fall plowed:							
Wheat	3	1.4	8.6	57.6	36.0	74.1	35.5
Oats	1	2.2	8.1	46.9	30.3	60.6	29.6
Barley	1	2.2	8.8	61.2	28.9	87.5	37.7
Flax	1	5.0	2.8	61.9	12.2	52.8	26.9
Total or average	6	2.3	7.6	57.1	29.9	70.5	33.5
Spring plowed:							
Wheat	1	2.0	22.5	60.0	36.2	70.3	38.2
Oats	1	3.1	9.1	47.8	34.7	51.6	29.3
Corn	2	1.7	10.0	69.7	46.8	65.1	38.7
Total or average	4	2.1	12.9	61.8	41.1	63.0	36.2
Sod breaking:							
Brome-grass	1	7.8	1.6	63.1	27.5	71.6	34.3
Clover	1	9.1	5.9	66.6	40.2	85.3	41.4
Total or average	2	8.5	3.8	64.9	33.9	78.5	37.9
Disked: Corn	4	2.5	15.0	64.1	42.5	65.5	37.9
Green manure:							
Rye	1	4.1	7.5	61.9	48.0	63.7	37.0
Peas	1	3.8	9.1	57.5	45.3	89.4	41.0
Total or average	2	4.0	8.3	59.7	46.7	76.6	39.1
Summer tilled	3	5.9	16.8	77.1	39.8	79.7	43.9
Average of all 21 plats	....	3.5	11.0	63.2	37.8	71.0	37.3

Summary of Yields and Digest of Cost.

Yields, values, etc. (average per acre).	Tillage treatment.					Previous crop.			
	Fall plowed (6 plats).	Spring plowed (4 plats).	Disked (4 plats).	Green manured (2 plats).	Summer tilled (3 plats).	Sod (2 plats).	Corn (6 plats).	Small grain (7 plats).	Flax (1 plat).
Yields of grain:									
1910 bushels	2.3	2.1	2.5	4.0	5.9	8.5	2.2	2.0	5.0
1911 do	7.6	12.9	15.0	8.3	16.8	3.8	13.3	10.6	2.8
1912 do	57.1	61.8	64.1	59.7	77.1	64.9	66.0	55.5	61.9
1913 do	29.9	41.1	42.5	46.7	39.8	33.9	43.9	34.0	12.2
1914 do	70.5	63.0	65.5	76.6	79.7	78.5	65.3	70.3	52.8
Average	33.5	36.2	37.9	39.1	43.9	37.9	38.1	34.5	26.9
Crop value, cost of production, etc.:									
Value	$10.05	$10.86	$11.37	$11.73	$13.17	....	....	....	....
Cost	6.31	5.84	4.50	14.36	11.25	....	....	....	....
Profit or loss	3.74	5.02	6.87	−2.63	1.92	....	....	....	....

The record of five years from Williston includes three years of heavy and two of very low production. When averaged for the five years the results do not show a wide variation in yields by different tillage methods. The yield of oats has been higher each year except 1910 by both spring and fall plowing when the crop followed wheat than when it followed oats. In every year except 1914 the yield has been higher following either wheat or oats when the land was spring plowed than when it was fall plowed.

The yields on disked corn ground have averaged higher than those on the stubble of any small grain plowed in the fall and approximately the same as on the stubble of wheat and corn plowed in the spring. The highest average yields have been produced by summer tillage. When cost of production is taken into consideration, it is seen in the last part of Table VII that the higher yields from summer tillage and green manure have been obtained at a cost proportionately greater than the increase in yields.

The only method showing production at a loss is that of green manuring. The smallest profit, $1.92 per acre, has been by summer tillage, which has given the highest yield. Disked corn ground, owing both to high yield and low cost, shows the greatest average profit, $6.87 per acre. The average profit from spring plowing has been $5.02 and from fall plowing $3.74.

DICKINSON FIELD STATION.

The soil at the field station at Dickinson, N. Dak., is somewhat lacking in uniformity. It is characterized as a sandy clay loam to a depth of approximately 5 feet. Below this depth is a lighter soil which in some cases becomes very sandy or pure sand. The soil has the capacity to retain a large supply of water and to give up a large proportion of it to the crop. This, together with the depth to which a crop may feed, makes it possible to store in this soil an exceptionally large quantity of water that can be recovered by the crop.

The results of six years are available for study from Dickinson Station. The crop in 1912 was destroyed by hail shortly before maturity and is not included in computing averages. The crop of 1914 was damaged at least 50 per cent by hail.

The average annual yields have ranged from 8.9 bushels in 1911 to 67.8 bushels in 1909. The averages for the six years by different methods of cultivation and cropping range from 29.6 bushels on fall-plowed oat ground to 49.9 bushels by summer tillage. While this is a comparatively wide range in results from different methods, it is apparent that the ability of a method to increase yields is dependent upon the season. It will be noted that in 1909, a season of heavy production, there were comparatively small differences in yield from different methods. In 1911, when the seasonal rainfall was very deficient, summer tillage and rye as green manure gave fair yields, while other methods were nearly or quite failures. During the years of average climatic conditions the differences in yields have not been so extreme, but with few exceptions summer tillage, green manuring, and disking corn ground have consistently given the best yields. The highest average, 49.9 bushels, for the five years has been by summer tillage. This is closely approached by rye as green manure with an average of 49 bushels and disked corn ground with an average of 47.5 bushels.

TABLE VIII.—*Yields and cost of production of oats by different methods at the Dickinson Field Station, 1908 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).							
		1908	1909	1910	1911	1912	1913	1914	Average.
Fall plowed:									
Wheat	3	37.9	63.6	32.0	2.0	(1)	60.2	17.9	35.6
Oats	1	32.8	58.4	26.0	1.6	(1)	44.4	14.4	29.6
Barley	1	44.7	61.9	27.8	1.4	(1)	61.0	19.5	36.1
Flax	1	30.0	61.9	26.8	2.2	(1)	62.2	19.2	33.7
Total or average	6	36.9	62.2	29.4	1.9	....	58.1	17.8	34.4
Spring plowed:									
Wheat	4	51.0	65.4	27.9	3.1	(1)	51.8	22.6	37.0
Oats	1	48.4	55.9	32.0	6.6	(1)	33.0	15.3	31.9
Corn	2	55.8	70.8	36.7	6.0	(1)	47.7	18.9	39.3
Total or average	7	52.0	65.6	31.0	4.4	....	48.0	20.5	36.9
Sod breaking:									
Alfalfa	1	65.6	75.3	33.7	1.1	(1)	45.3	22.8	40.6
Brome-grass	1	61.6	65.0	44.6	2.8	(1)	51.9	27.2	42.2
Clover	1	54.7	63.8	29.0	2.7	(1)	55.0	22.0	37.9
Total or average	3	60.6	68.0	35.8	2.2	....	50.7	24.0	40.2
Disked: Corn	5	65.0	75.6	40.7	12.8	(1)	64.2	26.7	47.5
Green manure:									
Rye	1	59.7	65.3	46.3	22.6	(1)	59.4	40.5	49.0
Peas	1	49.4	70.3	34.2	6.4	(1)	55.0	33.1	41.4
Sweet clover	1	65.3	69.7	28.0	8.6	(1)	57.8	21.2	41.8
Total or average	3	58.1	68.4	36.2	12.5	....	57.4	31.6	44.0
Summer tilled	3	57.7	70.1	47.2	29.8	(1)	57.1	37.4	49.9
Average of all 27 plats	....	53.3	67.8	35.4	8.9	....	55.6	24.5	40.9

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment.					Sod (3 plats).	Previous crop.		
	Fall plowed (6 plats).	Spring plowed (7 plats).	Disked (5 plats).	Green manured (3 plats).	Summer tilled (3 plats).		Corn (7 plats).	Small grain (10 plats).	Flax (1 plat).
Yields of grain:									
1908 bushels	36.9	52.0	65.0	58.1	57.7	60.6	62.4	44.4	30.0
1909 do	62.2	65.6	75.6	68.4	70.1	68.0	74.2	62.9	61.9
1910 do	29.4	31.0	40.7	36.2	47.2	35.8	39.6	29.3	26.8
1911 do	1.9	4.4	12.8	12.5	29.8	2.2	10.8	2.8	2.2
1912 do	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
1913 do	58.1	48.0	64.2	57.4	57.1	50.7	59.5	52.6	62.2
1914 do	17.8	20.5	26.7	31.6	37.4	24.8	24.5	19.3	19.2
Average	34.4	36.9	47.5	44.0	49.9	40.2	45.2	35.2	33.7
Crop value, cost, etc.:									
Value	$10.32	$11.07	$14.25	$13.20	$14.97	....	....	....	....
Cost	6.31	5.84	4.50	14.36	11.25	....	....	....	....
Profit or loss	4.01	5.23	9.75	—1.16	3.72	....	....	....	....

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[1] Destroyed by hail.

Spring plowing has averaged a little better than fall plowing, irrespective of the kind of stubble plowed. The relative merits of the two vary from year to year, depending upon the season and the condition of the ground at plowing time. Generally, when the ground is wet at the time of fall plowing, the better results are obtained from it. On the other hand, if fall plowing is done when the ground is dry, it has not been as good as spring plowing.

When the cost of production is considered, as in the second part of Table VIII, it is seen that the high cost of green manure has caused the growth of oats by this method to be done at a loss of $1.16 per acre. The high yields and low cost of preparation of disked corn ground have combined to make it show the largest profit of any method, $9.75 per acre. Intermediate between these are spring plowing with $5.23, fall plowing with $4.01, and summer tillage with $3.72 profit per acre, respectively.

EDGELEY FIELD STATION.

The field station at Edgeley, N. Dak., is located on a soil that is derived from the decomposition of shale, which in undecomposed particles is found very near the surface. In the third foot the shale, while broken and offering fairly free passage to water, is not as yet broken down into soil. The depth of feeding of crops is practically limited to the first 2 feet. The first foot carries an unduly large supply of water available to the crop. The limited depth of soil that functions in the storage of water and in the development of the crop, however, limits the quantity of available water that can be carried in the soil to about half that carried by soils of greater depth. This makes the crop practically dependent upon rains that fall while it is growing.

Edgeley offers for study of oat production an unbroken record of eight years. Five of the eight years have been productive of heavy crops from practically all methods, while three have been years of light production from practically all methods.

The range of yields from different methods of preparation and cropping as exhibited in the average of the eight years is comparatively small. This is as might be expected from the soil on which the station is located. Its shallowness makes the crop much more dependent upon the seasonal precipitation than it is in deeper soils. It is, consequently, impossible to realize much benefit from methods of cultivation calculated to store water in the lower zone of normal crop-feeding depth.

Oats on land which was summer tilled the previous year have produced an average yield of 38.3 bushels per acre, but this is only 4.8 bushels more than the average on disked corn ground and 6.4 bushels more than the average of all crops following small grain.

Table IX.—*Yields and cost of production of oats by different methods at the Edgeley*[1] *Field Station, 1907 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).								
		1907	1908	1909	1910	1911	1912	1913	1914	Average.
Fall plowed:										
Wheat	4	28.0	25.5	59.3	10.7	2.8	61.1	34.3	51.3	34.1
Oats	1	21.4	15.3	46.8	10.3	.3	60.3	21.5	30.0	25.7
Barley	1	32.5	15.9	60.3	14.3	1.6	57.8	27.5	48.5	32.3
Flax	1	......	22.5	53.1	15.6	.6	55.0	27.5	50.3	32.1
Total or average	7	27.6	21.7	56.7	11.8	1.9	59.6	30.5	47.7	32.2
Spring plowed:										
Wheat	2	29.7	20.6	54.2	9.7	2.4	56.2	46.4	44.0	32.9
Oats	1	21.3	16.9	57.5	6.2	.5	53.8	28.4	36.9	27.7
Corn	2	15.2	20.8	59.8	7.8	7.1	73.6	40.6	33.3	32.3
Total or average	5	20.4	19.8	57.1	8.2	3.9	62.7	40.5	38.3	31.4
Sod breaking:										
Alfalfa	1	......	9.7	48.7	3.8	.2	45.3	8.7	42.2	22.7
Brome-grass	1	33.8	16.3	55.0	8.1	.6	54.4	37.1	41.3	30.8
Clover	1	......	11.3	50.3	3.1	5.0	49.1	51.5	47.8	31.2
Total or average	3	33.8	12.4	51.3	5.0	1.9	49.6	32.5	43.8	28.8
Disked: Corn	7	28.2	20.1	55.4	7.9	3.7	60.5	43.6	48.2	33.5
Green manured:										
Rye	1	37.5	24.7	61.8	9.3	10.9	75.0	40.0	48.5	38.5
Peas	1	32.5	19.4	53.8	6.5	1.7	64.4	53.7	46.9	34.9
Sweet clover	1	......	19.4	45.3	7.1	.3	61.2	35.9	50.9	31.4
Total or average	3	35.0	21.2	53.6	7.6	4.3	66.9	43.2	48.8	35.1
Summer tilled	5	33.8	19.9	59.0	11.0	9.3	70.9	54.1	48.1	38.3
Average of all 30 plats	....	27.9	19.6	56.0	9.1	4.1	61.9	40.6	46.0	33.2

Summary of Yields and Digest of Cost.

Yields, values, etc. (average per acre).	Tillage treatment.					Previous crop.			
	Fall plowed (7 plats).	Spring plowed (5 plats).	Disked (7 plats).	Green manured (3 plats).	Summer tilled (5 plats).	Sod (3 plats).	Corn (9 plats).	Small grain (9 plats).	Flax (1 plat).
Yields of grain:									
1907 bushels	27.6	20.4	28.2	35.0	33.8	33.8	23.0	27.0	....
1908 do	21.7	19.8	20.1	21.2	19.9	12.4	20.3	20.8	22.5
1909 do	56.7	57.1	55.4	53.6	59.0	51.3	56.3	56.7	33.1
1910 do	11.8	8.2	7.9	7.6	11.0	5.0	7.9	10.3	15.6
1911 do	1.9	3.9	3.7	4.3	9.3	1.9	4.4	2.0	.6
1912 do	59.6	62.7	60.5	66.9	70.9	49.6	63.4	58.7	55.0
1913 do	30.5	40.5	43.6	43.2	54.1	32.5	42.9	34.2	27.5
1914 do	47.7	38.3	48.2	48.8	48.1	43.8	44.9	45.4	50.3
Average	32.2	31.4	33.5	35.1	38.3	28.8	32.9	31.9	32.1
Crop value, cost, etc.:									
Value	$9.66	$9.42	$10.05	$10.53	$11.49	....	....	....	....
Cost	6.31	5.84	4.50	14.36	11.25	....	....	....	....
Profit or loss	3.35	3.58	5.55	—3.83	.24	....	....	....	....

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[1] Additions were made to the work at this station in the spring of 1909. The number of plats shown in the average is the number from 1909 to 1913, but it is not in all cases correct for 1907 and 1908.

The yields of oats following rye plowed under for green manure have averaged practically the same as those on summer-tilled land. The yields following peas as a green manure have not averaged quite so high, while those following sweet clover have been still lower.

The average yield on alfalfa sod has been the lowest in the series. On both brome-grass and clover sods the average yields have been practically the same as after small grains.

The yield of oats following wheat on both spring-plowed and fall-plowed land appears to be better than when following oats on land so prepared.

Little difference is to be observed in the average results following either spring or fall plowing of small-grain stubble for oats. There are differences that develop with differences in seasons, but on the whole it would appear from the evidence at hand that the time for plowing for oats at this station would be determined chiefly, if not solely, by the matter of economy and convenience in doing the work.

When the cost of preparation by the different methods under study is taken into consideration, it is seen that this cost, rather than differences in yield, is the determining factor. The greatest average profit, $5.55 per acre, has been realized from oats on disked corn ground. Oats on spring-plowed and fall-plowed land have been productive of nearly equal profits of about $2 less. The slightly increased yield by summer tillage has not been sufficient to meet the increased cost of the method and profits from it have fallen to 24 cents per acre. Green manuring has been responsible for an average loss of $3.83 per acre.

HETTINGER FIELD STATION.

The soil at the field station at Hettinger, N. Dak., is a heavy clay loam. The seasons during which the work has been carried on have been such that the results of soil-moisture study are not yet conclusive in determining the proportion of water that can be stored in the soil and recovered by a crop. It is probable, however, that the depth of feeding is not limited by any physical peculiarity of the soil and that the supply of available water that can be stored is large. It is reasonable, therefore, to expect that on this soil the maximum effect will be realized from methods of tillage calculated to store water.

The results of three years of fair production are available from the Hettinger station. Records for this length of time are not so valuable an index to methods of production as the longer records at other stations in the State. It appears evident, both from the records and from field observations, that they are complicated somewhat by soil differences. While some of these differences are recognized in their manifestations, their nature has not been satisfactorily determined. In the study as here arranged, the most difficulty is offered by the two unduplicated plats of oats following oats, one prepared by spring plowing and the other by fall plowing. Both of these appear to have a higher yielding power than is consistent with the results at other stations in the State. That this is due in some measure to soil differences has been observed in the field.

TABLE X.—*Yields and cost of production of oats by different methods at the Hettinger Field Station, 1912, 1913, and 1914.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).			
		1912	1913	1914	Average.
Fall plowed:					
Wheat	3	19.0	17.9	22.2	19.7
Oats	1	36.3	28.1	29.4	31.3
Barley	1	34.4	20.0	27.5	27.3
Flax	1	17.2	21.5	17.5	18.7
Total or average	6	24.2	20.6	23.5	22.8
Spring plowed:					
Wheat	4	14.6	34.5	41.5	30.2
Oats	1	32.8	37.6	44.4	38.3
Corn	2	25.3	40.2	31.8	32.4
Total or average	7	20.3	36.5	39.1	32.0
Sod breaking:					
Alfalfa	1	17.2	24.7	17.2	19.7
Brome-grass	1	35.3	13.5	25.0	24.6
Clover	1	10.0	13.8	26.9	16.9
Total or average	3	20.8	17.3	23.0	20.4
Disked:					
Corn	6	26.0	41.8	38.8	35.5
Potatoes	1	23.7	38.2	36.0	32.6
Total or average	7	25.6	41.3	38.4	35.1
Green manured:					
Rye	1	22.5	19.7	17.8	20.0
Peas	1	17.5	26.0	23.8	22.4
Sweet clover	1	22.5	25.6	24.4	24.2
Total or average	3	20.8	23.8	22.0	22.2
Summer tilled	5	27.3	38.3	30.8	32.1
Average of all 31 plats	....	23.5	31.7	31.4	28.9

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment.					Previous crop.				
	Fall plowed (6 plats).	Spring plowed (7 plats).	Disked (7 plats).	Green manured (3 plats).	Summer tilled (5 plats).	Sod (3 plats).	Corn (8 plats).	Small grain (10 plats).	Flax (1 plat).	Potatoes (1 plat).
Yields of grain:										
1912....bushels..	24.2	20.3	25.6	20.8	27.3	20.8	25.8	21.9	17.2	23.7
1913.......do....	20.6	36.5	41.3	23.8	38.3	17.3	41.4	27.7	21.5	38.2
1914.......do....	23.5	39.1	38.4	22.0	30.8	23.0	37.0	33.4	17.5	36.0
Average	22.8	32.0	35.1	22.2	32.1	20.4	34.7	27.7	18.7	32.6
Crop value, cost, etc.:										
Value	$6.84	$9.60	$10.53	$6.66	$9.63	....	....	....	....	....
Cost	6.31	5.84	4.50	14.36	11.25	....	....	....	....	....
Profit or loss	.53	3.76	6.03	−7.70	−1.62	....	....	....	....	....

Spring plowing has given markedly better results than fall plowing in two of the three years. Disked corn ground and disked potato ground have been about equal to spring-plowed land in crop-producing power. Summer tillage has failed at this station to be productive of the increases in yields that have attended its use at the other stations in the State. In 1914 this may have been due to the fact that the fallows were allowed to become weedy in 1913.

The lowest yields have followed the breaking of sod and the use of green manure.

When methods are considered in broad groups and production is combined with cost, as in the second part of Table X, the data become more instructive. This shows that green manuring, the most expensive method, has been at the same time the least productive. Instead of providing a profit it has been a source of the greatest loss, $7.70 per acre. The disking of potato or corn ground is the least expensive preparation and has been the most productive of the general groups in bushels per acre, as well as in dollars per acre. It shows an average profit of $6.03.

Spring plowing and fall plowing both show profit, the greater profit being from the spring plowing.

Summer tillage, with its high production cost, gave only slightly greater yields and has not been able to pay for the labor and the use of the land. It is debited with an average loss of $1.62 per acre.

While the general trend of these results is reliable, it is very likely that their detail will be subject to change by the extension of the record.

BELLE FOURCHE FIELD STATION.

The field-station farm near Newell, S. Dak., on the Belle Fourche Reclamation Project, is located on a heavy gumbo clay soil. The soil is derived from decomposition of Pierre shale. From the soil at the surface there is a rapid change to broken but undecomposed shale. Near the bottom of the second foot is a comparatively impervious layer of soil. The first foot and at least a part of the second foot carry a large supply of available water. It is probable that but little use is made of either water or soil below the first 2 feet. In spite of the heavy soil and the large supply of water that can be obtained by the plant from that portion of it near the surface, the shallowness of feeding reduces the quantity of water that can be carried in the soil to about one-half of that available in deeper soils. The result of this is shown in the yields.

The results of six years are shown in Table XI. In one year production was heavy, in two years it was fair, in one it was very poor, and in 1911 the drought was so extreme that no method was able to overcome it. The preceding year had been so dry that practically no water was stored in the soil by any method.

TABLE XI.—*Yields and cost of production of oats by different methods at the Belle Fourche Field Station, 1909 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).						
		1909	1910	1911	1912	1913	1914	Average.
Fall plowed:								
Wheat	3	54.3	0	0	6.2	16.8	12.7	15.0
Oats	1	46.9	0	0	6.6	15.8	24.7	15.7
Barley	1	65.6	0	0	11.4	23.1	12.2	18.7
Flax	1	64.7	0	0	0	16.3	22.8	17.3
Total or average	6	56.7	....	....	6.1	17.6	16.3	16.1
Spring plowed:								
Wheat	1	42.5	6.9	0	9.5	16.9	15.0	15.1
Oats	1	48.8	9.2	0	11.7	17.8	13.0	16.8
Corn	2	60.5	8.3	0	7.2	20.1	23.7	20.0
Total or average	4	53.1	8.2	....	8.9	18.7	18.8	18.0
Sod breaking:								
Alfalfa	1	65.0	0	0	0	16.3	13.0	15.7
Brome-grass	1	67.7	0	0	7.0	25.9	12.0	18.8
Clover	1	63.8	[a] 8.1	0	[1] 16.7	13.1	12.2	19.0
Total or average	3	65.5	2.7	....	7.9	18.4	12.4	17.8
Subsoiled: Oats	1	60.8	0	0	7.3	16.3	20.3	17.5
Listed: Oats	1	56.7	7.2	0	8.6	18.7	21.4	18.8
Disked;								
Corn	6	58.9	7.6	0	10.9	25.6	30.6	22.3
Sorghum	1	57.3	5.2	0	10.3	18.1	21.1	18.7
Potatoes	1	51.9	9.8	0	10.6	29.7	35.9	23.0
Total or average	8	57.8	7.6	....	10.8	25.2	30.1	21.9
Green manured:								
Rye	1	69.4	9.2	0	4.8	31.3	29.5	24.0
Peas	1	76.6	11.3	0	4.7	32.8	28.1	25.6
Sweet clover	2	50.9	0	0	7.3	27.1	34.6	20.0
Total or average	4	61.9	5.1	....	6.0	29.6	31.7	22.4
Summer tilled	5	74.2	17.4	0	8.1	34.8	44.2	29.8
Average of all 32 plats	....	60.9	6.8	....	8.2	23.9	26.3	21.0

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment.							Previous crop.					
	Fall plowed (6 plats).	Spring plowed (4 plats).	Disked (8 plats).	Listed (1 plat).	Subsoiled (1 plat).	Green manured (4 plats).	Summer tilled (5 plats).	Sod (3 plats).	Corn (8 plats).	Small grain (9 plats).	Flax (1 plat).	Sorghum (1 plat).	Potatoes (1 plat).
Yields of grain:													
1909......bushels..	56.7	53.1	57.8	56.7	60.8	61.9	74.2	65.5	59.3	53.8	64.7	57.3	51.9
1910.........do....	0	8.2	7.6	7.2	0	5.1	17.4	2.7	7.8	2.6	0	5.2	9.8
1911.........do....	0	0	0	0	0	0	0	0	0	0	0	0	0
1912.........do....	6.1	8.9	10.8	8.6	7.3	6.0	8.1	7.9	10.0	8.2	0	10.3	10.6
1913.........do....	17.6	18.7	25.2	18.7	16.3	29.6	34.8	18.4	24.2	17.7	16.3	18.1	29.7
1914.........do....	16.3	18.8	30.1	21.4	20.3	31.7	44.2	12.4	28.9	16.1	22.8	21.1	35.9
Average	16.1	18.0	21.9	18.8	17.5	22.4	29.8	17.8	21.7	19.7	17.3	18.7	23.0
Crop value, cost, etc.:													
Value	$4.83	$5.40	$6.57	$5.64	$5.25	$6.72	$8.94	.....	.....	.....	.....	.....	.....
Cost	6.31	5.84	4.50	5.30	6.92	14.36	11.25	.....	.....	.....	.....	.....	.....
Profit or loss	−1.48	− .44	2.07	.34	−1.67	−7.64	−2.31	.....	.....	.....	.....	.....	.....

[a] There was no stand of clover before oats.

The highest yields have followed summer tillage, peas and rye as green manure, and disking potato and corn ground.

Listing has given a little higher yields than plowing similar stubble. Subsoiling is of doubtful advantage. Its average is slightly greater than the average of similar stubble plowed either in the fall or in the spring. There has been, however, no consistency in the results from year to year.

In spite of the combination of bad seasons, disked ground shows an average profit of $2.07. With the exception of one plat cropped to potatoes and one plat cropped to sorghum, the disked land was previously in corn. Listing shows a nominal profit and spring plowing a nominal loss. Both fall plowing and subsoiling show losses of about $1.50 per acre. Summer tillage has the highest yield, but the practice of this method has resulted in an average loss of $2.31 per acre. Green manure, with a yield only slightly above the average and with the highest cost of production, is debited with a loss of $7.64 per acre.

SCOTTSBLUFF FIELD STATION.

The work at Scottsbluff, Nebr., is conducted at a field station located on the North Platte Irrigation Project. The soil is a comparatively light sandy loam. At a depth varying from 5 to 8 feet there is a sharp break from sandy loam to either sand or Brulé clay. Above this point the soil offers no unusual resistance to the downward passage of water or to the development of roots. Owing to its light character, however, it is possible to store in it only a moderate supply of available water. While the evidence on this point is not yet complete, the proportion of water that can be stored in this soil is known to be somewhere intermediate between the corresponding capacities of the Belle Fourche and the North Platte soils.

The results of three years are available from the Scottsbluff station. In each of these years production was largely determined by the supply of water available to the crop both from the rainfall and from the water stored in the soil. Consequently, considerable differences in production from differences in preparation were brought out.

The highest yields each year have been produced on land summer tilled the previous year. The average yield, 38.2 bushels per acre, from this method is over twice that from fall-plowed land that had raised a crop of small grain.

The next highest yields have been those from the green-manured plats. Between peas and rye for green manure the difference is small and not consistent from year to year.

Disked corn ground stands third in average yield of oats, but it owes this position to a very high yield in one year only.

Spring plowing has, on the whole, given better results than fall plowing, although the one plat following oats on spring plowing has been the poorest in the field. This plat is plowed shallow and given little cultivation. It also has a poor location in the field and results from it are entitled to little weight.

TABLE XII.—*Yields and cost of production of oats by different methods at the Scottsbluff Field Station, 1912, 1913, and 1914.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).			
		1912	1913	1914	Average.
Fall plowed:					
Wheat	4	11.5	20.4	20.2	17.4
Oats	1	21.6	16.9	14.7	17.7
Barley	1	9.0	22.2	15.9	15.7
Flax	1	38.4	25.0	10.0	24.5
Total or average	7	16.4	20.8	17.3	18.2
Spring plowed:					
Wheat	2	25.5	25.8	14.4	21.9
Oats	1	19.4	15.0	8.4	14.3
Corn	2	33.8	20.8	13.9	22.8
Sorghum	1	35.0	39.7	14.4	29.7
Total or average	6	28.8	24.7	13.2	22.2
Sod breaking:					
Alfalfa	1	41.9	13.4	5.6	20.3
Brome-grass	2	(1)	27.6	14.4	21.0
Clover	1	(1)	20.0	17.8	18.9
Total or average	4	41.9	22.1	13.0	25.7
Subsoiled: Oats	1	27.8	17.5	15.9	20.4
Listed: Oats	1	25.3	23.1	12.8	20.4
Disked: Corn	8	43.0	19.8	16.0	26.3
Green manured:					
Rye	2	34.6	35.3	21.4	30.4
Peas	3	29.6	29.4	23.4	27.5
Total or average	5	31.6	31.8	22.6	28.7
Summer tilled	4	45.5	44.0	25.0	38.2
Average of all 36 plats	......	32.3	25.4	17.3	25.0

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment.							Previous crop.			
	Fall plowed (7 plats).	Spring plowed (6 plats).	Disked (8 plats).	Listed (1 plat).	Sub-soiled (1 plat).	Green manured (5 plats).	Summer tilled (4 plats).	Corn (10 plats).	Small grain (11 plats).	Sod (4 plats).	Flax (1 plat).
Yields of grain:											
1912....bush..	16.4	28.8	43.0	25.3	27.8	31.6	45.5	41.1	18.2	41.9	38.4
1913....do....	20.8	24.7	19.8	23.1	17.5	31.8	44.0	20.0	20.7	22.1	25.0
1914....do....	17.3	13.2	16.0	12.8	15.9	22.6	25.0	15.6	16.1	13.0	10.0
Average....	18.2	22.2	26.3	20.4	20.4	28.7	38.2	25.6	18.3	25.7	24.5
Crop value, cost, etc.:											
Value.......	$5.46	$6.66	$7.89	$6.12	$6.12	$8.61	$11.46	......	......	......	......
Cost........	6.31	5.84	4.50	5.30	6.92	14.36	11.25	......	......	......	......
Profit or loss.....	— .85	.82	3.39	.82	— .80	—5.75	.21	......	......	......	......

[1] In 1911 brome-grass and clover did not come up, so these plats were summer tilled, and, therefore, the yields are not figured in these tables.

Subsoiling and listing show small increases over similar stubble fall plowed.

The shortness of the record and the inconsistency among the yields make it unsafe to base conclusions on such small differences.

When cost of production is considered in connection with yields it is seen that the only things that stand clearly by themselves are disked corn ground, with an average profit of $3.39 per acre, and the use of green manure, with a loss of $5.75. The other methods as grouped here show either losses or gains so small as to be subject to changes in their relative positions by a single crop.

NORTH PLATTE FIELD STATION.

The work here presented is conducted on the table-land of the North Platte Field Station. The soil is of the type generally known as loess. With the exception of the humus accumulated near the surface, it is practically uniform to great depths. The storage and use of water is unlimited by the depth of the soil or any peculiarities in it. The development of roots is limited only by the physiological character of the crops grown and the available moisture. It is a soil on which a maximum of results from tillage methods would be expected.

The North Platte Field Station presents for study the records of eight years. In three of these years the production has been good, in three it has been poor, and in two years the crop has been a failure.

Spring-plowed wheat stubble has given better results than fall plowing in five of the six years that have produced crops, but the great difference in favor of fall plowing in 1908 reduces the average gain from spring plowing to less than 2 bushels per acre.

On the plats continuously cropped to oats fall plowing has given better results than spring plowing in four of the six years, the average advantage in favor of it being more than 4 bushels per acre. The spring-plowed plat following oats is the only one in the series that is given shallow plowing.

Fall plowing oats after oats has been consistently better than after wheat, while with spring plowing the reverse has been the case. The poorest yields have been obtained following alfalfa and brome-grass. These two crops exhaust the available soil moisture and leave the following crop entirely dependent upon seasonal rainfall. Oats following them have usually been the first to suffer from drought.

Disked corn ground shows about the same average yields of oats as the crop raised after small grains.

Oats following green manure show a small increase in average yields over all other methods except that of summer tillage. Little difference is to be observed between the results following the use of peas and of rye for this purpose.

TABLE XIII.—*Yields and cost of production of oats by different methods at the North Platte Field Station, 1907 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	1907	1908	1909	1910	1911	1912	1913	1914	Average.
Fall plowed:										
Wheat	4	30.9	61.0	24.4	7.3	0	9.7	0	7.9	17.7
Oats	1	36.0	68.5	24.1	11.9	0	10.6	0	14.7	20.7
Barley	1	23.1	49.1	20.0	6.6	0	14.7	0	10.0	15.4
Total or average	6	30.5	60.2	23.6	7.9	......	10.7	......	9.4	17.8
Spring plowed:										
Wheat	2	34.5	47.7	32.8	12.5	0	18.6	0	9.1	19.4
Oats	1	30.0	34.4	31.3	11.3	0	18.7	0	5.0	16.3
Corn	2	34.6	54.3	31.3	12.2	0	14.4	0	9.7	19.6
Sorghum	1	30.0	45.0	28.8	8.1	0	12.5	0	7.8	16.5
Total or average	6	33.0	47.2	31.4	11.5	......	16.2	......	8.4	18.5
Sod breaking:										
Alfalfa	1	24.0	36.8	14.4	2.5	0	12.5	0	7.2	12.2
Brome-grass	1	22.2	40.0	16.6	4.7	0	7.2	0	5.6	12.0
Total or average	2	23.1	38.4	15.5	3.6	......	9.9	......	6.4	12.1
Disked: Corn	1	40.6	53.4	22.5	11.9	0	6.6	0	7.8	17.9
Green manured:										
Rye	2	30.5	73.8	[a]32.5	16.4	0	10.3	0	10.0	21.7
Peas	2	28.5	75.8	34.8	14.6	0	13.8	0	9.7	22.2
Total or average	4	29.5	74.8	34.0	15.5	......	12.0	......	9.9	22.0
Summer tilled	4	34.3	87.1	37.3	26.2	0	19.6	0	14.9	27.4
Average of all 36 plats	....	31.4	61.8	28.4	13.1	......	13.7	......	9.8	19.8

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment.					Previous crop.			
	Fall plowed (6 plats).	Spring plowed (6 plats).	Disked (1 plat).	Green manured (4 plats).	Summer tilled (4 plats).	Sod (2 plats).	Corn (3 plats).	Small grain (9 plats).	Sorghum (1 plat).
Yields of grain:									
1907...bushels..	30.5	33.0	40.6	29.5	34.3	23.1	36.6	31.3	30.0
1908......do....	60.2	47.2	53.4	74.8	87.1	38.4	54.0	54.6	45.0
1909......do....	23.6	31.4	22.5	34.0	37.3	15.5	28.3	26.5	28.8
1910......do....	7.9	11.5	11.9	15.5	26.2	3.6	12.1	9.3	8.1
1911......do....	0	0	0	0	0	0	0	0	0
1912......do....	10.7	16.2	6.6	12.0	19.6	9.9	11.8	13.3	12.5
1913......do....	0	0	0	0	0	0	0	0	0
1914......do....	9.4	8.4	7.8	9.9	14.9	6.4	9.1	8.8	7.8
Average	17.8	18.5	17.9	22.0	27.4	12.1	19.0	18.0	16.5
Crop value, cost of production, etc.:									
Value	$5.34	$5.55	$5.37	$6.60	$8.22	....	....	....	....
Cost	6.31	5.84	4.50	14.36	11.25	....	....	....	....
Profit or loss	− .97	− .29	.87	−7.76	−3.03	....	....	....	....

[a] Only 1 plat in 1909.

The heaviest yields have been those following summer tillage, exceeded only by disked corn ground in 1908. But when the cost of production is taken into consideration, as in the last part of Table XII, it is shown that the average increase in production due to summer tillage has not been sufficient to pay for its increased cost as compared with several other methods. It shows a loss of $3.03 per acre. Disked corn ground with its smaller yield shows an average profit of 87 cents per acre. Spring and fall plowing with about the same yields as disked corn ground have just about paid expenses. The use of green manure, with a high production cost and an average yield of only 22 bushels per acre, has resulted in an average loss of $7.76 per acre.

AKRON FIELD STATION, COLO.

The soil of the field-station farm at Akron, Colo., is of a clay-loam type, locally known as "tight land." It is characterized in the native vegetation by a growth of short grass. As it carries in each unit section a considerable supply of water, and as it offers no physical resistance to the development of roots, it is possible to store in it a large quantity of water available to a crop. It is a soil on which maximum results would be expected by practicing methods of tillage calculated to store water.

Of the six years offered for study from this station, two years have been productive of good crops of oats, two of light crops, and two of poor. They do not show in their average a very wide range in yields as a result of different cultural or cropping practices. The heaviest yields have followed summer tillage, which has given an average for the six years of 28.7 bushels per acre. The next highest yield, 25.3 bushels per acre, has been from spring-plowed corn ground. This has been only 1 bushel per acre more in its yield than spring-plowed wheat stubble.

Green manuring has barely maintained yields as high as those from land on which a crop of grain was harvested.

Disked land shows a strong advantage in its yields of oats in favor of corn as a preceding crop, as compared with the use of sorghum, milo, and kafir as preceding crops.

The poorest yields of oats have been obtained following alfalfa and brome-grass sods and on disked sorghum land.

Oats following wheat have been better by both spring and fall plowing than oats following oats.

The relative merits of fall and spring plowing appear to be dependent on the season, but the average of the seasons under study is slightly in favor of spring plowing.

Subsoiling, when compared with plowing at the same time without subsoiling, has been done at the expense of sharp reductions in yield.

Furrowing with a lister and leaving the ground rough through the winter has produced slightly greater average yields than plowing similar stubble either in the fall or spring.

TABLE XIV.—*Yields and cost of production of oats by different methods at the Akron Field Station, 1909 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).						
		1909	1910	1911	1912	1913	1914	Average.
Fall plowed:								
Wheat	3	19.3	14.1	10.5	47.7	7.6	35.5	22.5
Oats	1	14.1	8.0	15.9	46.9	.6	36.9	20.4
Barley	1	20.8	10.2	15.9	37.2	.6	39.1	20.6
Total or average	5	18.6	12.1	12.7	45.4	4.8	36.5	21.7
Spring plowed:								
Wheat	1	18.3	14.8	1.7	46.9	16.6	47.5	24.3
Oats	1	21.1	10.9	4.3	41.9	6.6	39.4	20.7
Corn	2	21.6	20.8	5.3	49.6	5.0	49.4	25.3
Total or average	4	20.6	16.8	4.2	47.0	8.3	46.4	23.9
Sod breaking:								
Alfalfa	1	8.8	2.7	0	29.4	1.9	30.6	12.2
Brome-grass	1	20.2	2.2	0	27.5	1.6	35.0	14.4
Total or average	2	14.5	2.5	0	28.5	1.8	32.8	13.4
Subsoiled: Oats	1	16.1	11.3	8.4	35.3	0	30.3	16.9
Listed: Oats	1	15.6	11.1	5.3	54.7	3.6	40.9	21.9
Disked:								
Corn	7	20.9	18.2	.4	38.5	7.3	48.5	22.3
Sorghum	1	16.1	5.0	0	25.0	1.9	37.8	14.3
Milo	2	15.7	12.2	0	41.9	7.2	40.7	19.6
Kafir	2	14.6	6.7	0	40.3	5.5	40.5	17.9
Total or average	12	18.6	14.2	.2	38.2	6.5	45.0	20.5
Green manured:								
Rye	1	21.0	20.0	2.7	38.4	5.0	44.4	21.9
Peas	1	22.0	11.9	0	38.4	1.2	38.1	18.6
Sweet clover	1	13.0	5.2	3.9	45.8	5.0	41.6	19.1
Total or average	3	18.7	12.4	2.2	40.9	3.7	41.4	19.9
Summer tilled	3	28.9	17.1	7.1	56.4	16.5	45.9	28.7
Average of all 31 plats		19.4	13.3	4.0	42.3	6.6	42.2	21.3

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment.							Previous crop.					
	Fall plowed (5 plats).	Spring plowed (4 plats).	Disked (12 plats).	Listed (1 plat).	Subsoiled (1 plat).	Green manured (3 plats).	Summer tilled (3 plats).	Sod (2 plats).	Corn (9 plats).	Small grain (9 plats).	Milo (2 plats).	Sorghum (1 plat).	Kafir (2 plats).
Yields of grain:													
1909..bush	18.6	20.6	18.6	15.6	16.1	18.7	28.9	14.5	21.1	18.2	15.7	16.1	14.6
1910..do	12.1	16.8	14.2	11.1	11.3	12.4	17.1	2.5	18.7	12.1	12.2	5.0	6.7
1911..do	12.7	4.2	.2	5.3	8.4	2.2	7.1	0	1.5	9.2	0	0	0
1912..do	45.4	47.0	38.2	54.7	35.3	40.9	56.4	28.5	40.9	45.1	41.9	25.0	40.3
1913..do	4.8	8.3	6.5	3.6	0	3.7	16.5	1.8	6.8	5.6	7.2	1.9	5.5
1914..do	36.5	46.4	45.0	40.9	30.3	41.4	45.9	32.8	48.7	37.9	40.7	37.8	40.5
Average	21.7	23.9	20.5	21.9	16.9	19.9	28.7	13.4	23.0	21.4	19.6	14.3	17.9
Crop value, cost, etc.:													
Value	$6.51	$7.17	$6.15	$6.57	$5.07	$5.97	$8.61	......	......	......	......	......	......
Cost	6.31	5.84	4.50	5.30	6.92	14.36	11.25	......	......	......	......	......	......
Profit or loss	.20	1.33	1.65	1.27	−1.85	−8.39	−2.64	......	......	......	......	......	......

When the value of the average crop is studied in connection with the cost of its production, as in the last part of Table XIV, less difference is perhaps found in the resulting profits or losses than in the yields themselves. To this statement should be excepted green manuring, which has not been productive of increases in yields at all commensurate with their cost. The use of this method has been responsible for an average loss of $8.39 per acre.

Profits and losses by all other methods come within a range of about $2 per acre. These differences are not sufficient to warrant strong recommendation of any particular method as essentially better than others. The indications of the evidence at hand are that the growth of oats will about pay for the use of land and for labor and other expenses incurred in their growth.

HAYS FIELD STATION.

The soil on which the experimental work has been conducted at the station at Hays, Kans., is a heavy silt loam. It carries a large supply of water available to a crop. Penetration to the lower depth, however, is slow. The very compact zone in the third foot offers marked resistance both to the downward passage of water and to the development of roots. While the evidence is not as complete as might be desired, it appears that the proportion of water that can be stored in this soil is somewhat above the average.

The work at Hays was started in 1906. The crop that year was raised on land uniform for all plats. The crop of 1907 was largely destroyed by the green bug (spring-grain aphis); hence, it is not included in the table. The crop of 1909 was entirely destroyed by hail and is not included in computing average yields. Its inclusion would only serve to reduce the averages, and reduce the differences obtained from cultural conditions in other years. The crop of 1911 is included in computing the averages as its failure was due to drought. Oats after wheat on both fall-plowed and spring-plowed land have been better than where oats followed oats.

Fall plowing of both wheat and oat stubble has been better for the production of oats than spring plowing of similar stubble.

The yields given for oats following sod land, both brome-grass and alfalfa, are comparatively high. They are, however, misleading and should not be given weight as a measure of the producing value of sod at this station, as there never has been in this work a heavy or well-established sod to break up.

The plat subsoiled and the one listed have both been continuously cropped to oats. They should be compared directly with the oats following oats on fall-plowed land. While there is little difference between the results of either subsoiling or listing, both have produced higher yields than plowing in either the fall or spring.

Table XV.—*Yields and cost of production of oats by different methods at the Hays Field Station, 1908 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).							
		1908	1909	1910	1911	1912	1913	1914	Average.
Fall plowed:									
Wheat	3	23.8	(1)	25.3	0	44.3	9.8	29.2	22.1
Oats	1	3.7	(1)	16.6	0	37.7	10.6	27.0	15.9
Barley	1	35.5	(1)	30.2	0	25.6	8.1	29.2	21.4
Total or average	5	22.1	......	24.5	......	39.2	9.6	28.7	20.7
Spring plowed:									
Wheat	1	26.0	(1)	36.6	0	19.0	6.2	22.3	18.4
Oats	1	1.3	(1)	11.3	0	35.2	3.3	20.8	12.0
Corn	2	17.2	(1)	32.0	0	36.4	11.3	23.2	20.0
Total or average	4	15.4	......	28.0	......	31.8	8.0	22.4	17.6
Sod breaking:									
Alfalfa	1	22.5	(1)	37.5	0	30.5	4.5	25.9	20.2
Brome grass	1	30.1	(1)	36.4	0	33.5	5.1	25.8	21.8
Total or average	2	26.3	......	37.0	......	32.0	4.8	25.9	21.0
Subsoiled: Oats	1	17.9	(1)	24.5	0	45.1	21.8	26.6	22.7
Listed: Oats	1	28.0	(1)	17.0	0	47.6	15.3	29.7	22.9
Disked:									
Corn	1	16.3	(1)	16.9	0	39.0	13.0	30.6	19.3
Sorghum	1	22.1	(1)	36.2	0	27.2	17.6	29.1	22.0
Total or average	2	19.2	......	26.6	......	33.1	15.3	29.9	20.7
Summer tilled	2	16.2	(1)	24.5	3.7	41.1	30.3	33.0	24.8
Average of all 17 plats	....	20.1	......	26.6	.4	37.0	12.8	27.5	20.7

Summary of Yields and Digest of Cost.

Yields, values, etc. (average per acre).	Tillage treatment.						Previous crop.			
	Fall plowed (5 plats).	Spring plowed (4 plats).	Disked (2 plats).	Listed (1 plat).	Subsoiled (1 plat).	Summer tilled (2 plats).	Sod (2 plats).	Corn (3 plats).	Sorghum (1 plat).	Small grain (9 plats).
Yields of grain:										
1908 bushels	22.1	15.4	19.2	28.0	17.9	16.2	26.3	16.9	22.1	20.4
1909 do	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
1910 do	24.5	28.0	26.6	17.0	24.5	24.5	37.0	26.9	36.2	23.6
1911 do	0	0	0	0	0	3.7	0	0	0	0
1912 do	39.2	31.8	33.1	47.6	45.1	41.1	32.0	37.3	27.2	38.1
1913 do	9.6	8.0	15.3	15.3	21.8	30.3	4.8	11.9	17.6	10.5
1914 do	28.7	22.4	29.9	29.7	26.6	33.0	25.9	25.7	29.1	27.0
Average	20.7	17.6	20.7	22.9	22.7	24.8	21.0	19.8	22.0	19.9
Crop value, cost of production, etc.:										
Value	$6.21	$5.28	$6.21	$6.87	$6.81	$7.44	......	......	......	......
Cost	6.31	5.84	4.50	5.30	6.92	11.25	......	......	......	......
Profit or loss	—.10	—.56	1.71	1.57	—.11	—3.81	......	......	......	......

[1] Destroyed by hail.

Corn ground, either spring plowed or disked, has not produced as good crops of oats as wheat stubble plowed in the fall. The yield from disked sorghum ground has been slightly better than from disked corn ground.

Summer tillage has a slightly higher average than any other method of preparation for oats. The increase in yield, however, over other methods is small.

Differences in average yields from different methods have been so small that the cost of production is the determining factor in profits or losses.

Disked land and listed land, owing to fair average yields and low cost of production, have shown profits.

Fall plowing, spring plowing, and subsoiling have produced crops just about sufficient to pay for their cost.

Summer tillage is debited with a loss of $3.81 per acre.

GARDEN CITY FIELD STATION.

The work at Garden City, Kans., is on a high upland. The soil is a light silt loam. With the exception of the accumulated humus near the surface, it is practically uniform to a depth of at least 15 feet. The development of roots is limited only to the depth to which water is available and by the physiological character of the crop. The light character of the soil, however, makes it possible to store in each unit of it only a comparatively small proportion of water. This is not entirely overcome by the depth of soil. The results in storing water have been determined largely by the limited quantity available for storage. In no year under any method practiced has the soil been filled with water to as great a depth as it is possible for the crop to develop roots and to use available water.

During the six years covered by the production of oats at this station, two years have been total failures, one from drought and one from hail. In 1912 and 1914 sufficient grain was produced to offer some encouragement to the growing of this crop. The production during the other two years was very light.

The chief value in presenting these records is to show that oats are not well enough adapted to prevailing conditions and yield too poorly to justify their growth on any considerable area. Under such circumstances, oats should give way to crops better adapted to this region.

The highest average yields of oats have been obtained on summer-tilled land and on listed land, which produced an average of 12.8 bushels per acre.

None of the yields have been large enough to pay for cost of production and, in general, the more expensive the method the greater the loss resulting from its practice.

TABLE XVI.—*Yields and cost of production of oats by different methods at the Garden City Field Station, 1909 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).						
		1909	1910	1911	1912	1913	1914	Average.
Fall plowed:								
Wheat	3	2.1	6.6	0	17.0	(1)	13.3	7.8
Oats	1	3.2	10.3	0	23.1	(1)	8.1	8.9
Barley	1	3.1	10.0	0	29.7	(1)	12.8	11.1
Total or average	5	2.5	8.0	....	20.8	....	12.2	8.7
Spring plowed:								
Wheat	1	1.3	7.2	0	21.9	(1)	....	7.6
Oats	1	1.0	5.3	0	8.8	(1)	2.2	3.5
Corn	2	3.1	7.4	0	22.9	(1)	....	8.4
Total or average	4	2.1	6.8	....	19.1	....	2.2	6.0
Subsoiled: Oats	1	2.6	10.0	0	15.9	(1)	17.3	9.2
Listed: Oats	1	2.2	11.6	0	27.8	(1)	22.2	12.8
Disked:								
Corn	8	1.5	9.3	0	21.8	(1)	12.2	9.0
Sorghum	1	0	7.5	0	8.8	(1)	....	4.1
Milo	2	.6	5.7	0	28.0	(1)	....	8.6
Kafir	2	1.2	5.5	0	27.1	(1)	....	8.5
Total or average	13	1.2	8.0	....	22.5	....	12.2	8.8
Green manure:								
Rye	1	1.5	12.8	0	20.2	(1)	10.5	9.0
Peas	1	.9	12.8	0	22.5	(1)	....	9.1
Total or average	2	1.2	12.8	....	21.4	....	10.5	9.2
Summer tilled	3	4.6	16.2	0	25.8	(1)	17.2	12.8
Average of all 28 plats	....	2.0	9.2	0	22.0	....	13.1	9.3

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc., (average per acre).	Tillage treatment.							Previous crop.				
	Fall plowed (5 plats).	Spring plowed (4 plats).	Disked (13 plats).	Listed (1 plat).	Subsoiled (1 plat).	Green manured (2 plats).	Summer tilled (3 plats).	Corn (10 plats).	Small grain (9 plats).	Sorghum (1 plat).	Milo (2 plats).	Kafir (2 plats).
Yields of grain:												
1909...bushels	2.5	2.1	1.2	2.2	2.6	1.2	4.6	1.8	2.2	0	0	1.2
1910......do	8.0	6.8	8.0	11.6	10.0	12.8	16.2	8.9	8.2	7.5	5.7	5.5
1911......do	0	0	0	0	0	0	0	0	0	0	0	0
1912......do	20.8	19.1	22.5	27.8	15.9	21.4	25.8	22.0	19.8	8.8	28.0	27.1
1913......do	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
1914......do	12.2	2.2	12.2	22.2	17.3	10.5	17.2	12.2	12.8	(2)	(2)	(2)
Average	8.7	6.0	8.8	12.8	9.2	9.2	12.8	9.0	8.6	4.1	8.6	8.5
Crop value, cost, etc.:												
Value	$2.61	$1.80	$2.64	$3.84	$2.76	$2.76	$3.84	......	......	......	......	......
Cost	6.31	5.84	4.50	5.30	6.92	14.36	11.25	......	......	......	......	......
Loss	—3.70	—4.04	—1.86	—1.46	—4.16	—11.60	—7.41	......	......	......	......	......

(1) Destroyed by hail.

(2) Discontinued.

DALHART FIELD STATION.

The soil at Dalhart is a sandy loam. In some respects it behaves like sand. In other respects it exhibits the characteristics of a heavy clay soil. Its water-holding capacity is comparatively limited. The crops appear, however, to be able to utilize its water to the depth of a normal development.

TABLE XVII.—*Yields and cost of production of oats by different methods at the Dalhart Field Station, 1909 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).						
		1909	1910	1911	1912	1913	1914	Average.
Fall plowed:								
Wheat	3	0	(1)	0	(1)	0	15.8	4.0
Oats	1	0	(1)	0	(1)	0	26.4	6.6
Barley	1	0	(1)	0	(1)	0	16.2	4.1
Total or average	5						18.0	4.5
Spring plowed:								
Wheat	1	0	(1)	0	(1)	0	13.7	3.4
Oats	1	0	(1)	0	(1)	0	14.3	3.6
Corn	2	0	(1)	0	(1)	0		0
Total or average	4						14.0	3.5
Sod breaking:								
Alfalfa	1	5.9	(1)	0	(1)	0		2.0
Brome	1	0	(1)	0	(1)	0		0
Total or average	2	3.0						1.0
Listed: Oats	1	0	(1)	0	(1)	0	23.4	5.9
Disked:								
Corn	6	0	(1)	0	(1)	0	16.7	4.2
Sorghum	1	0	(1)	0	(1)	0	15.0	3.8
Milo	2	0	(1)	0	(1)	0		0
Kafir	2	0	(1)	0	(1)	0		0
Total or average	11						15.9	4.0
Green manured:								
Rye	1	0	(1)	0	(1)	0		0
Peas	1	0	(1)	0	(1)	2.0		.7
Total or average	2					1.0		.3
Summer tilled	3	12.1	(1)		(1)	3.3	21.6	9.3
Average of all 27 plats		1.5				.4	18.0	5.0

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[1] Destroyed by hail.

TABLE XVII.—*Yields and cost of production of oats by different methods at the Dalhart Field Station, 1909 to 1914, inclusive*—Continued.

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment.						Previous crop.					
	Fall plowed (5 plats).	Spring plowed (4 plats.)	Disked (11 plats).	Listed (1 plat).	Green manured (2 plats).	Summer tilled (3 plats).	Corn (8 plats).	Sorghum (1 plat).	Small grain (8 plats).	Sod (2 plats).	Milo (2 plats).	Kafir (2 plats).
Yields of grain:												
1909.....bushels..	0	0	0	0	0	12.1	0	0	0	3.0	0	0
1910.......do....	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
1911.......do....	0	0	0	0	0	0	0	0	0	0	0	0
1912.......do....	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)	(1)
1913.......do....	0	0	0	0	1	3.3	0	0	0	0	0	0
1914.......do....	18.0	14.0	15.9	23.4	....	21.6	16.7	15.0	17.7	......	......	......
Average........	4.5	3.5	4.0	5.9	.3	9.3	4.2	3.8	4.4	1.0	0	0
Crop value, cost of production, etc.:												
Value............	$1.35	$1.05	$1.20	$1.77	$0.09	$2.79	......	......	......	......	......	......
Cost.............	6.31	5.84	4.50	5.30	14.36	11.25	......	......	......	......	......	......
Loss..........	−4.96	−4.79	−3.30	−3.53	−14.27	−8.46	......	......	......	......	......	......

[1] Destroyed by hail.

Much the same work has been done with oats at Dalhart as at the other field stations. Determined efforts have been made for six years to grow this crop under a wide range of methods of preparation and culture, but without success. It has been variously destroyed by hail, drought, and soil blowing. The few crops that have been harvested were grown on summer-tilled land, but the yields have been so low, both actually and in comparison with other crops better adapted to the region, as to furnish no indication of their profitable production.

The low yields and high percentage of failures of oats at this station resulting from each and all of the various methods of tillage employed indicate little possibility of overcoming conditions by any cultural practices. This indication is strengthened when the time covered by these tests is considered. It can only be concluded that the combination of soil and climatic conditions existing at this station is not congenial to the production of oats.

The grain sorghums have produced good crops of feed every year at this station and have made good average grain yields. As compared with these crops oats has no place in the cropping system under conditions similar to those at this station.

AMARILLO FIELD STATION.

The soil at Amarillo, Tex., is a heavy clay silt. It is of the type locally known as "tight land" or "short-grass land." While the evidence is not as complete as could be desired, it appears that the storage of water and the development of the feeding roots of the crop are interfered with by a comparatively impervious layer of soil in the third foot. The soil above this, however, is competent to take care of all the water that it has been possible to store, even under a system of alternate cropping.

The results of six years are available from Amarillo. The year 1910 was lost by reason of an enforced change in the location of the station. In three of the six years yields have been fair and in three they have been very poor.

Only one method of preparation—summer tillage—has departed very far in its results from the general average. The average yield by this method has been 27.6 bushels per acre. The extreme range in the average of all other methods is from 13.2 bushels on spring-plowed wheat stubble to 18.4 bushels on peas as green manure and on fall plowing after barley. There is little profit in discussing differences within so narrow a range of yields.

It may be noted that fall plowing of either wheat or oat stubble has been better than spring plowing of either. Subsoiling has not been productive of yields as high as those by fall plowing similar stubble. Furrowing with a lister and leaving the ground rough through the winter has been practically as good as plowing.

Disking corn ground has given about the same results as plowing it. Disked milo and kafir ground have given markedly poorer results than corn ground.

The yields following green manure have corresponded closely to those following a harvested crop rather than to those following summer tillage.

When the cost of production is considered in connection with the value of the average crops produced by different methods, it is seen that the more expensive methods—summer tillage, subsoiling, and green manuring—have been the cause of losses ranging from $2.39 to $9.17. Fall plowing, spring plowing, and listing also show small losses. The low cost of preparation of disked land has resulted in its showing a profit of $0.24 per acre.

TABLE XVIII.—*Yields and cost of production of oats by different methods at the Amarillo Field Station, 1909 to 1914, inclusive.*

Treatment and previous crop.	Number of plats averaged.	Yield per acre (bushels).						
		1909	1910	1911	1912	1913	1914	Average.
Fall plowed:								
Wheat	3	26. 7	14. 3	26. 4	9. 7	6. 8	19. 0	17. 2
Oats	1	32. 2	0	27. 5	14. 1	2. 5	30. 9	17. 9
Barley	1	31. 3	0	35. 6	9. 1	7. 2	26. 9	18. 4
Total or average	5	28. 7	8. 6	28. 5	10. 5	6. 0	23. 0	17. 6
Spring plowed:								
Wheat	1	23. 4	0	35. 7	9. 7	3. 1	7. 5	13. 2
Oats	1	20. 0	0	28. 2	9. 7	0	29. 4	14. 6
Corn	2	21. 9	0	36. 0	17. 2	1. 4	21. 1	16. 3
Total or average	4	21. 8	....	34. 0	13. 5	1. 5	19. 8	15. 1
Subsoiled: Oats	1	28. 1	0	19. 2	8. 8	4. 1	30. 6	15. 1
Listed: Oats	1	29. 7	0	26. 8	11. 6	6. 9	26. 9	17. 0
Disked:								
Corn	6	22. 7	0	28. 7	14. 3	3. 4	33. 4	17. 1
Milo	2	19. 3	0	25. 9	11. 9	1. 9	28. 8	14. 6
Kafir	2	16. 5	0	26. 7	8. 2	1. 8	26. 8	13. 3
Total or average	10	20. 8	....	27. 7	12. 6	2. 8	31. 1	15. 8
Green manure:								
Rye	1	31. 9	5. 0	18. 0	13. 8	5. 6	22. 2	16. 1
Peas	1	27. 5	8. 4	25. 9	15. 0	6. 5	26. 9	18. 4
Total or average	2	29. 7	6. 7	22. 0	14. 4	6. 1	24. 6	17. 3
Summer tilled	2	32. 5	24. 4	36. 2	17. 7	17. 4	37. 1	27. 6
Average of all 25 plats	....	24. 8	4. 2	28. 7	12. 7	4. 9	27. 4	17. 1

SUMMARY OF YIELDS AND DIGEST OF COST.

Yields, values, etc. (average per acre).	Tillage treatment.							Previous crop.			
	Fall plowed (5 plats).	Spring plowed (4 plats).	Disked (10 plats).	Listed (1 plat).	Subsoiled (1 plat).	Green manured (2 plats).	Summer tilled (2 plats).	Corn (8 plats).	Small grain (9 plats).	Milo (2 plats).	Kafir (2 plats).
Yields of grain:											
1908 .bush	28. 7	21. 8	20. 8	29. 7	28. 1	29. 7	32. 5	22. 5	27. 2	19. 3	16. 5
1909...do	8. 6	0	0	0	0	6. 7	24. 4	0	4. 8	0	0
1911...do	28. 5	34. 0	27. 7	26. 8	19. 2	22. 0	36. 2	30. 5	28. 0	25. 9	26. 7
1912...do	10. 5	13. 5	12. 6	11. 6	8. 8	14. 4	17. 7	15. 0	10. 2	11. 9	8. 2
1913...do	6. 0	1. 5	2. 8	6. 9	4. 1	6. 1	17. 4	2. 9	4. 9	1. 9	1. 8
1914...do	23. 0	19. 8	31. 1	26. 9	30. 6	24. 6	37. 1	30. 3	23. 2	28. 8	26. 8
Average	17. 6	15. 1	15. 8	17. 0	15. 1	17. 3	27. 6	16. 9	16. 4	14. 6	13. 3
Crop value, cost of production, etc.:											
Value	$5. 28	$4. 53	$4. 74	$5. 10	$4. 53	$5. 19	$8. 28	......	......	......	......
Cost	6. 31	5. 84	4. 50	5. 30	6. 92	14. 36	11. 25	......	......	......	......
Profit or loss	−1. 03	−1. 31	. 24	− . 20	−2. 39	−9. 17	−2. 97	......	......	......	......

GENERAL DISCUSSION OF RESULTS.

In the preceding pages data have been presented and briefly discussed separately for each station without reference to results at other stations. In the following pages the data are considered from a more general standpoint. Table XIX will assist in this study.

In this table the average yields at the several stations are grouped under different methods of preparation. The figures here given are taken from the tables showing details for each station.

Data in regard to yields and cost of production are also assembled in such a way as to show the profit or loss in dollars and cents per acre for the average crop for each method for which it has been computed at each station.

TABLE XIX.—*Comparison of the average yields and profit or loss in the production of oats by different methods at fourteen stations in the Great Plains area.*

Statement of data.	Number of years averaged.	Methods of tillage.						
		Fall plowed.	Spring plowed.	Listed.	Subsoiled.	Disked.	Green manured.	Summer tilled.
1	2	3	4	5	6	7	8	9
Yields per acre (bushels):[1]								
Judith Basin	5	49.9	51.2	49.9	49.5	53.3	54.8	58.4
Huntley	2	43.4	49.2	47.2	46.1	53.0	58.6	59.2
Williston	5	33.5	36.2	....	....	37.9	39.1	43.9
Dickinson	6	34.4	36.9	....	....	47.5	44.0	49.9
Edgeley	8	32.2	31.4	....	....	33.5	35.1	38.3
Hettinger	3	22.8	32.0	....	....	35.1	22.2	32.1
Belle Fourche	6	16.1	18.0	18.8	17.5	21.9	22.4	29.8
Scottsbluff	3	18.2	22.2	20.4	20.4	26.3	28.7	38.2
North Platte	8	17.8	18.5	....	....	17.9	22.0	27.4
Akron	6	21.7	23.9	21.9	16.9	20.5	19.9	28.7
Hays	6	20.7	17.6	22.9	22.7	20.7	....	24.8
Garden City	6	8.7	6.0	12.8	9.2	8.8	9.2	12.8
Dalhart	4	4.5	3.5	5.9	....	4.0	.3	9.3
Amarillo	6	17.6	15.1	17.0	15.1	15.8	17.3	27.6
Average[1]	5	24.4	25.8	24.1	24.7	28.3	28.7	34.3
Profit or loss (—) per acre:								
Judith Basin	5	$8.66	$9.52	$9.67	$7.93	$11.49	$2.08	$6.27
Huntley	2	6.71	8.92	8.86	6.91	11.40	3.22	6.51
Williston	5	3.74	5.02	....	....	6.87	— 2.63	1.92
Dickinson	6	4.01	5.23	....	....	9.75	— 1.16	3.72
Edgeley	8	3.35	3.58	....	....	5.55	— 3.83	.24
Hettinger	3	.53	3.76	....	....	6.03	— 7.70	—1.62
Belle Fourche	6	—1.48	— .44	.34	—1.67	2.07	— 7.64	—2.31
Scottsbluff	3	— .85	.82	.82	— .80	3.39	— 5.75	.21
North Platte	8	— .97	— .29	....	....	.87	— 7.76	—3.03
Akron	6	.20	1.33	1.27	—1.85	1.65	— 8.39	—2.64
Hays	6	— .10	— .56	1.57	— .11	1.71	....	—3.81
Garden City	5	—3.70	—4.04	—1.46	—4.16	—1.86	—11.60	—7.41
Dalhart	6	—4.96	—4.79	—3.53	....	—3.30	—14.27	—8.46
Amarillo	6	—1.03	—1.31	— .20	—2.39	.24	— 9.17	—2.97

[1] The averages of columns 3, 4, 7, and 9 only are comparable.

On the whole, seasonal conditions have produced much wider variations in yields than have been produced by differences in cultivation. Some seasons are so favorable that any and all methods give good returns at stations where oats can be successfully grown.

Other seasons have been so unfavorable at some stations that no method of cultivation has been able to produce a crop of oats. Less common than either of these are the seasons when there is just the combination of factors nearly or quite to prohibit production by some methods while allowing others to produce good crops. When the results of a series of years are averaged together, as must be done in a continuous agriculture, the wide differences obtained in exceptional years tend to be much reduced.

Perhaps the first thing that impresses one in viewing the average yields from all stations is the much better adaptation of oats to the northern than to the southern section of the Great Plains. There is an almost constant decrease in yields from the northern stations having cooler, shorter seasons to the southern stations having warmer, longer seasons. This decrease is about the same for the heavier yielding as it is for the lighter yielding methods. This proves that there is a lack of adaptation of the crop to the combination of soil and climatic conditions existing at the southern stations. The fact that all methods fail to produce even fair average yields at these stations shows that this lack of adaptation can not be overcome by cultural practices.

General averages for all of the stations mean little, because differences in yield obtained at one station may be balanced by differences in an opposite direction at another station.

The division into the two general groups of fall plowing and spring plowing is a striking example of such compensation of differences and the resulting lack of difference in the general average. With the trifling exception of a fraction of a bushel at Edgeley, spring plowing at all stations north of Hays has given higher averages than fall plowing. At Hays and the stations south of it fall plowing has been in about an equal degree better than spring plowing. The greater number of stations represented in the northern group makes the general average of averages show a small margin in favor of spring plowing. This, however, is of no binding force or value to those stations whose results show fall plowing to be the better practice for them.

At all stations north of North Platte disking has been productive of higher average yields than either fall plowing or spring plowing. At North Platte, Dalhart, and Amarillo it is between the two. At Hays it is the same as fall plowing and higher than spring plowing, and at Garden City it is higher than either. In the general average of all the stations reported it has a yield of 28.3 bushels per acre, against 25.8 bushels for spring plowing and 24.4 bushels for fall plowing. The great bulk of the land disked is corn ground, as is shown in detail in the tables for each station.

With the exception of a sharp decrease from subsoiling at Akron and a similar increase from listing at Garden City, the yields from each of these practices have not departed far from the yields of ordinary plowing. Some of the details of departure or lack of it have been discussed in dealing with separate stations where closer comparisons could be drawn with exactly similar stubble.

Green manuring averaged as a group was productive of higher yields than either fall or spring plowing or disking corn ground at 9 of the 13 stations for which results with this method are reported. At Dickinson this method was exceeded by disking corn ground. At Hettinger, Akron, and Dalhart green manuring gave poorer yields than any of the three other methods mentioned. At Amarillo this method gave yields exceeding those by fall plowing.

Of all the methods under trial, as grouped in Table XIX, summer tillage produced the highest yields at every station except Hettinger, where is was exceeded only by yields on disked corn ground. Averaged for all the stations, its increase of yield over fall plowing lacked one-tenth of a bushel of being 10 bushels per acre. The greatest departure from this general average was at Scottsbluff, where the increase was 20 bushels per acre.

Sod breaking as a preparation for oats has very generally stood at or near the bottom of the list, as is discussed in some detail under each station where it has been on trial.

As values and cost of production are here figured, it is seen in Table XIX that oats have been produced at a profit by at least one method at all stations except Garden City and Dalhart. At two stations, Judith Basin and Huntley, a profit has been realized by all methods.

Generally speaking, good yields have combined with low cost of production to make disked land which has been chiefly corn ground show the greatest profit at all stations where a profit has been realized from any method.

At all stations where it has been tried, listing either has been more profitable or has resulted in less loss than fall plowing.

Subsoiling has yielded a profit at two stations and a loss at six. It can not be said, however, that it was a profitable practice at any station, as its profits were less and its losses greater than those of fall plowing. It should be compared with fall plowing, as it is a modification of that method.

At all the ten stations north of Hays, except Belle Fourche and North Platte (where the losses were 44 cents and 29 cents, respectively), spring plowing was productive of profitable crops. At Hays the average loss from it was only 56 cents per acre. At Amarillo the loss increased to $1.31. At Garden City and Dalhart spring plowing, in common with all other methods, shows a loss.

At Akron, Colo., and at all North Dakota and Montana stations fall plowing showed a profit. At Scottsbluff the nominal profits from spring plowing were converted to nominal losses by fall plowing. At the other stations the losses by the two methods were about the same.

The cost of green manuring was so high that at only two stations, Judith Basin and Huntley, did it show a profit. At these stations the profits were smaller than those by any other method. At all other stations it either converted the profit of other methods into a loss or was productive of the greatest loss of any method. In probably only two or three cases has the loss been small enough to make it possible to change it to a profit by distributing a part of the cost to following crops.

Summer tillage as here figured shows a profit at six stations and a loss at eight. In two cases the profits are nominal, i. e., they are so small that changes in the average yields by extension of the record might change their position. In no case was the profit as here figured as great as by some other method. Except at Dalhart and Garden City, the average losses at those stations showing a loss have ranged from $1.62 to $3.81. Considering the fact shown in the details from the separate field stations, it seems that as summer tillage sometimes produced a crop when other methods failed it might have a place in the production of oats, even though somewhat greater net profits may be obtained in the average of a series of years by other methods. Sureness of production, especially of feed crops, is as important as the amount of net profit per acre, if not more important.

A reference to the companion publication on spring wheat (Bulletin 214 of the Department series) will show that the relative response of oats to summer tillage is somewhat greater than that of spring wheat.

CONCLUSIONS.

(1) The relatively poor adaptation of oats to the southern section of the Great Plains can not be overcome by cultivation.

(2) Seasonal conditions cause much wider variations in yields than can be caused by differences in cultivation.

(3) When the results of a series of years are averaged, as must be done in a continuous agriculture, the great differences which are obtained only in exceptional years tend to be much reduced.

(4) At stations north of Hays, spring plowing has been generally more productive of oats than fall plowing. At Hays and the stations south of it fall plowing has been in about an equal degree better than spring plowing.

(5) At Garden City and all stations north of North Platte, disking corn ground has been productive of higher average yields of oats

than either fall or spring plowing. At North Platte, Hays, Dalhart, and Amarillo it yielded either the same as one of them or its place was intermediate between the two.

(6) With the exception of a sharp decrease at Akron, the yields by subsoiling have not departed far from those by ordinary plowing. It has not been a profitable practice, as the profits by it have been less and the losses greater than by fall plowing, of which it is a modification and with which it should be compared.

(7) At all stations where it has been tried, listing for oats has been either more profitable or has resulted in less loss than fall plowing.

(8) Green manuring has been productive of higher yields than either fall or spring plowing, or disking corn ground, at nine of the thirteen stations from which results by it are reported. The cost of production by this method was so high that it showed a profit at only two stations.

(9) Oats following summer tillage produced the highest average yields at all stations except Hettinger, where the yield was exceeded only by that on disked corn ground. While the expense of the method has prevented its being the most profitable, the degree of insurance which it affords against failure of the feed crop might justify its practice in oat production in at least some sections of the Great Plains.

(10) Disking corn ground yielded the highest profits of any method tested at all stations except Garden City and Dalhart. At these two stations the crop was produced at a loss, but this loss was less than by any other method.

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